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Technical Memorandum

Bunker Hill Mine Flood-Stanly Ore Body In-Mine Reconnaissance Report

Bunker Hill Mine Water Presumptive Remedy

Prepared for

U.S. Environmental Protection Agency Region 10

September 1999

147843

Prepared by

CH2MHILL

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Bunker Hill Mine Flood-Stanly Ore Body In-Mine Reconnaissance Report
(Supplement 2 to the Presumptive Remedy Conceptual Model)

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DATE: September 8, 1999

1.0 Introduction

This technical memorandum presents the findings of the Flood-Stanly Ore Body in-mine reconnaissance conducted as part of EPA's presumptive remedy process for the Bunker Hill Mine. The reconnaissance consisted of 9 days of underground field work conducted between April 16, and June 16, 1999 in accordance with the approved Flood-Stanly Reconnaissance Plan, dated April 2, 1999. Each day of reconnaissance was conducted by Bill Hudson and John Riley, with Nick Zilka of the Idaho Division of Environmental Quality joining when available.

1.1 Objectives

Underground field reconnaissance was performed to improve understanding of recharge to, flow within, and discharge from the Flood-Stanly ore body. Previous investigators have identified the Flood-Stanly ore body as the primary acid producing area in the Bunker Hill Mine. However, the details of flow paths and dynamics were largely unknown. The four objectives of this underground reconnaissance effort were as follows. Reconnaissance findings and recommendations for each of these objectives is discussed in the Summary and Recommendations section.

Objective 1—Identify surface water and groundwater recharge mechanisms to the workings.

Objective 2—Identify acid producing areas of the workings.

Objective 3—Understand mine water flow paths within the workings and evaluate the potential for mine water diversions.

Objective 4—Identify missing hydraulic, acid, and metal load within the upper country loop (9LA and its tributaries) identified during the current mine water monitoring program.

1.2 Background

1.2.1 Access

Exploration of accessible areas from 3 Level to 8 Level provided a greater understanding of the details of mine water flow related to the Flood-Stanly workings. Surface access to these areas was from either the Reed Portal, the Homestake Portal, the Sullivan No. 2 Portal, or the Utz Portal. Appendix A contains daily reconnaissance logs which describes the access routes for each day of reconnaissance.

Accessibility to the underground workings on 3 to 8 Level varied from good to non-existent. Some workings are staying open with little or no support and maintenance even though most active mining of the ore body ended in the early 1950s, and even though little or no maintenance has taken place since then. In addition, a bulk mining technique, called block caving was used to extract some of the ore body. That technique has left significant volumes of collapsed and unstable ground, particularly below the Guy Caving area. Access to some areas was also prevented by bulkheads constructed in the drifts by the miners. However, even with the obstacles to access, it was found for all areas visited that airflow was good, and oxygen supply was not compromised.

1.2.2 Water Flow Complexity

The upper workings are very complex and contain many drifts, sublevels, and open stopes that are not shown on any existing mine maps. This necessitated field mapping to fill out the details of water flow paths as they exist presently. These maps are in Appendix B.

The underground water flow paths were also found to be very complex. Drifts and ditches are constructed with very flat gradients. The flat gradients are susceptible to changes in flow paths because of chemical precipitation, physical deposition of material, and/or erosion. Many flow divides exist on some levels, and sub-levels. Flow between levels is controlled mainly by service raises, ore transfer chutes, stopes and other manmade openings. Fracture flow also allows inter-level transfer of water. Fracture transfer typically is much slower than flow through manmade openings.

The flat gradients can lead to the development of ponds that can remain stagnant during much of the year. During spring runoff and flood events, water is flushed out of the ponds. Often water quality deteriorates as water sits in ponds, because of the prevalence of pyrite in the Flood-Stanly workings. Floods can occur in response to spring runoff, changes in hydraulic characteristics and dynamics along recharge pathways, breaching of chemical or constructed dams, movement of muck in ore chutes, and other factors.

Some preliminary observations regarding the timing of recharge to specific areas of the Flood-Stanly ore body are presented. Additional observation and data interpretations will be required to test these hypotheses. Three distinct mechanisms appears to influence recharge. The first mechanism consist of localized thawing in the very near-surface workings. This occurred when ambient outdoor temperatures were below freezing. The other two mechanisms appear to be low snow melt and high snow melt. The locations, elevations, slopes, aspects, and other variables that distinguish between these are not precisely known.

1.2.3 Relative Water Quality

Relative water quality was evaluated using field measurements of specific electrical conductivity (EC). Two tables of EC, containing measurements at 82 locations, are presented in Appendix C. The first is organized chronologically (and consequently spatially). The second is organized by decreasing EC, to facilitate quick identification of the locations that have the worst (or best) relative water quality.

2.0 Reconnaissance Findings

This section presents the findings and observations of the reconnaissance. The findings are presented in the general order of shallow to deeper workings. This section presents an overview of the flow paths and illustrates some of the complexity associated with the underground recharge/discharge. No attempt is made to present extensive details of each flow path, because these could not be determined due to the complexities noted in Section 1.2.2. Please refer to the associated figures in Appendix B for details of flow paths that were documented.

2.1 Above 5 Level

2.1.1 Utz and Homestake (Figures 1 and 2)

The Utz workings are the highest and shallowest workings that are accessible in the vicinity of the Flood-Stanly ore body. Water recharges the Utz from the surface along preferential fracture flow paths. Most of the water that enters the Utz workings flows into the sub-levels below, and eventually into the Homestake workings. Some water at the western end of the Utz enters an open stope and drains to the Cherry 4 workings. These flow paths consist of fractures, stopes, transfer chutes, raises, and other man-made openings. Recharge to the Homestake workings consists of drainage from the overlying Utz, and groundwater recharge via fractures.

The Utz and Homestake workings are developed in or near the hanging wall of the Cate Fault. The ore zones consist of fine grained, gray gouge material that contains large amounts of disseminated pyrite as well as economic minerals. Generally, the pyrite is very fine-grained gray material, but some large (6 inch diameter) assemblages occur.

All of the water from the Homestake workings discharges to the sub-level below via fractures, transfer chutes, raises and other man-made openings. From that sub-Level, the water discharges into an open stope. This was mistakenly identified as a caving area in Bretherton (1990). The bottom of this stope is approximately at 4 1/2 Level. The water from the Homestake appears to discharge from fractures, drill holes, and rock bolt holes at the end of the Asher drift on 5 Level. Tracer testing or other methods would be required to confirm this.

It was observed during mine water monitoring events this winter that recharge to the Utz and Homestake occurred during January and February, when snow covered the surface above the workings and ambient outside temperatures were generally below freezing. This suggests that recharge began early in response to local heating, probably from pyrite oxidation in the workings and remaining pyritic ore/gouge material. Recharge continued, but to a lesser degree during low elevation snowmelt in the West Milo and South Milo drainages.

The quality of the surface recharge water generally is good to excellent. However, water that enters along the mineralized veins degrades along the short flow path from the surface to the workings—sometimes a distance of less than 50 feet. Water in the underground workings that is ponded by muck dams or undulation in the drift degrades rapidly because of widespread occurrence of fine-grained pyrite.

2.2 4 Level

2.2.1 Cherry 4 (Figures 3, 4, and 5)

The Cherry 4 working are adjacent to and approximately 20 feet lower than the sublevel below the Homestake workings. Part of the Cherry 4 was developed during the block caving of the Flood-Stanly; other parts were developed later during the mining of the Utz and Homestake. Recharge to Cherry 4 consists of groundwater recharge via fractures, rock bolt holes, drill holes, and drainage from overlying workings via raises, transfers, and stopes.

The quality of recharge water is good in a few locations. Generally, however, the water quality is fair to poor, because of flow through pyrite-rich ore zones and ponding in contact with pyrite-rich muck. The range of EC is from 3,000 to 30,000 μS/cm.

Discharge from Cherry 4 consists of drainage through transfers and collapsed ground, and into stopes. The water flows generally to the western parts of 5 Level in the vicinity of the underground greenhouse. Cross sections of the Utz, Homestake, and Cherry 4 are presented in Figures 6 and 7. Please refer to Figures 1, 2, and 4 for the cross section locations.

2.2.2 Bunker Hill 4

The Bunker Hill 4 Level workings are developed at an elevation between the Cherry 4 and the 5 Level Reed workings. They are accessible off a ramp above the Asher drift, and a service raise from the greenhouse. The maps that we have do not present the full extent of the Bunker Hill 4 workings.

Recharge to Bunker Hill 4 appears to be dominated by flow from overlying workings via fractures, raises and transfers. The water discharges via fractures, raises and transfers. Most of it appears to drain to the western part of 5 Level. However, some may bypass 5, and discharge directly to 6.

Many ponds exist, and water quality is generally poor. EC varies from 7,000 to 40,000 μS/cm.

2.3 5 and 6 Levels

2.3.1 5 Level (Figures 8, 9, 10, and 11)

Recharge to 5 Level workings consists of groundwater recharge via fractures, rock bolt holes, drill holes, and drainage from overlying workings via raises, transfers, and stopes.

Tributary flows to the underground greenhouse include drainages from fractures, transfer raises, and manways. Water flows vertically from Cherry 4 and Bunker Hill 4 workings and laterally from groundwater recharge through fractures.

The quality of groundwater recharge is good to excellent (EC < 200 μS/cm). Drainage from overlying workings varies from excellent to poor (EC from 66 to 44,000 μS/cm).

Water draining from the stope identified in the discussion of the Homestake workings, plus water from other fracture systems, flows through drawpoints at the end of the Asher Drift to a ramp down to the 5 Level Reed workings. This ramp was developed during the late stages of Bunker Limited Partnership operations (1990's), and is not shown on any existing mine maps. The flow divides, with a small portion draining toward the greenhouse, and flowing through the monitoring station at 5WR. The majority of this water flows toward the West Motor Drift through a pond that is too deep to walk through with hip boots. Presumably, the water somehow reaches the Mule Raise between 5 and 6 Level. Access via the West Motor drift is blocked slightly beyond the Mule Raise by a cave in, so physical verification was impossible.

The majority of drainage from the Flood-Stanly Ore Body and Guy Caving operations (west side of 5 Level) flows from the underground greenhouse to the West Reed Flume (5WR) where it is monitored. The water continues along the West Reed drift, where discharge from transfer chutes improves the water quality slightly. It flows to the Becker Flume (5BK) through a breakthrough into the Motor Vein, and eventually to the Mule Raise near 6 level. Some of the water from the greenhouse drains directly down to 6 Level, in the vicinity of the underground crusher station, via ore transfer chutes, service raises, and possibly collapsed ground. The water near the 6 Level crusher station is directly tributary to the Stanly Ore Chute on 9 Level, or the Cherry Raise which drains to 9 level.

Discharge from the greenhouse is generally less than 10 gallons per minute (gpm), but the water quality is very poor. EC is generally greater than 10,000 μS/cm, with a maximum of 44,600 μS/cm. Discharge from fractures and ore chutes improves the water quality between the greenhouse and the Becker Flume. EC ranges from less than 100 to 4,700 μS/cm.

Drainage from the other (east) side of 5 Level is monitored at the Williams Flume (5WM). Tributary flows include groundwater recharge via fractures, drill holes, rock bolt holes and drainage from stopes. Other recharge sources include drainage from transfers, manways and other constructed openings. Water quality in the east side of 5 Level is relatively good to excellent. EC ranges from less than 100 to approximately 500 μS/cm.

The timing of recharge on the west side of 5 Level generally appears to be in response to low elevation snow melt, with minor contributions from earlier drainage from the Utz and Homestake workings. Peak recharge on the east side of 5 Level occurs slightly later than on the west side, suggesting either a longer flow path, or higher elevation snow melt.

2.3.2 6 Level (Figures 12 and 13)

Discharge from 5 Level, via the Becker (Mule) Raise and Williams Winze, constitutes the majority of flow on 6 Level. Other sources include recharge from fractures and transfers in the greenhouse, drainage down the ramp from the New East Reed drift on 5 Level, drainage from stopes - primarily the Hanna Stope, and recharge of groundwater.

Water from the west side of 5 Level (5BK) reaches the Mule Raise on 6 Level. Water from the east side of 5 Level (5WM) flows down the Williams Winze to 6 Level. That water flows across 6 Level to a large transfer located east of the Mule Raise. Both of these flows presumably reach 7 Level and eventually reaches the Van Raise and discharges to the 9 Level Bunker Hill East Drift, and is monitored at 9 VR. Physical verification of the flow paths below 6 1/2 Level was not possible. The Mule Raise becomes very steep, and existing ladders were badly corroded; access to 7 Level from the Cherry Raise was blocked.

The underground crusher station was constructed for service during the Guy Caving operations in the late 1940's and early 1950's. Consequently, many ore transfers from overlying Guy Caving workings are tributary to the crusher. The ore was crushed and transferred to 9 Level via ore chutes to the Stanly Crosscut.

A flow divide exists near the underground crusher station on 6 Level. A portion of that water flows east to the Cherry Raise and down to 9 Level. The remaining water flows west to the ore transfers that are tributary to the Stanly Crosscut, also on 9 Level.

2.4 7 and 8 Levels

2.4.1 7 Level (Figures 14 and 15)

Access to 7 Level is largely blocked. A well constructed bulkhead blocks access to, and discharge from, the Flood-Stanly workings. The bulkhead probably is blocking discharge from Flood-Stanly workings and diverting it down to 8 Level via transfers or other manmade structures. The main drift in the opposite direction is also blocked. Approximately 20 gpm of relatively good quality water discharges from the lacing just before the bulkhead (EC 1640 μS/cm). That water drains down the Cherry Raise.

The most significant flow on 7 Level comes from a single diamond drill hole at the end of the Kateye drift, straight ahead off the Cherry Raise. The water is of relatively excellent quality, with a historical EC of approximately 100 μS/cm. The typical discharge rate is approximately 100 gpm, with seasonal increases that occur mid to late summer. This water drains toward the Cherry Raise, to an ore transfer raise that discharges on 9 Level, approximately 50 feet from the bottom of the Cherry Raise.

2.4.2 8 Level (Figures 16, 17, and 18)

Eight Level provides good access to the Flood-Stanly workings. Flow was low in mid-June when the reconnaissance of this level was conducted, and it appeared that peak flow had already occurred. However, it appeared that major discharges onto 8 Level from transfers and raises from 7 and/or 6 Levels had occurred in the recent past. The majority of 8 Level water flows into transfers, stopes, and other manmade openings, and is very likely the flow path for major discharge to the Stanly Crosscut on 9 Level.

The major flows appear to have washed significant quantities of muck out of the ore chutes onto 8 Level, and deposited the material onto the tracks and into the ditches. This appears to have diverted more water toward the Cherry Raise than had flowed that direction previously (mid-1980's). This is probably partially responsible for the increased flow down the Cherry Raise, as compared to historical data.

Relative water quality was fair to poor. EC ranged from 3,500 to 15,500 µS/cm. The flow with the highest EC (poorest quality) was that which discharges directly to the Cherry Raise.

2.5 9 Level (Figure 19)

Discharge from the Flood-Stanly workings to 9 Level is mainly to ore transfers that discharge into the Stanly Crosscut, and to the Cherry Raise. These locations are monitored at 9SX, 9SO and 9CR. Some discharge from the shallow Flood-Stanly workings flows via a circuitous path to the Van Raise. This flow is monitored at 9VR.

Water quality at 9SX, 9SO, and 9CR is consistently poor. EC varies from 5,000 to 19,000 µS/cm. Water quality at 9VR is generally fair, with EC readings between 1,000 and 2,000 µS/cm.

The timing of peak flow on 9 Level indicates that high elevation snow melt controls this flow path. Surface runoff and infiltration peaked in the West Fork of Milo Creek at the same time that peak discharge occurred in these 9 Level locations. This suggests that the likely mechanism is snowmelt that recharges the hanging wall of the Guy Caving area. Additional investigation would be required to confirm this hypothesis.

3.0 Implications of Findings to Potential Mitigations

Section 1.1 listed the four reconnaissance objectives. The following sections describe the current level of understanding for each objective.

3.1 Objective 1

Objective 1 was to identify surface water and groundwater recharge mechanisms to the workings. Surface water and shallow groundwater are the predominant mechanisms that recharge the Flood-Stanly ore body. It is unlikely that deeper groundwater along fracture systems is a major contributor to Flood-Stanly recharge. The following three mechanisms appear to control the majority of recharge to the Flood-Stanly.

Infiltration of local snow melt appears to recharge shallowest workings directly from the overlying snowpack. Recharge to the Utz and Homestake workings began when outside ambient temperatures remained below freezing and snow was still accumulating. The most probable source of heat is the exothermic oxidation of pyrite in those workings, warming the thin cap rock and alluvium that overlies the workings.

Low elevation snowmelt probably recharges 4, 5, and 6? Levels in most years. The probable mechanism is direct infiltration of the snow pack on and in the immediate vicinity of the guy Caving area. Low snow was virtually nonexistent in 1999. As a result, the spring flush of water through those levels was small. The timing of the small runoff peak in 1999 suggests a low elevation control on the recharge.

High elevation snowmelt appears to dominate recharge to the Flood-Stanly ore body on 8 and 9 Levels It may also recharge 7 Level, but that was inaccessible this year. The probable mechanism is infiltration of runoff and shallow groundwater into the hanging wall of the Guy Caving area. A fracture flow path in the hanging wall would bypass the shallower workings (4, 5, and 6 Levels). Alternately, recharge from high snowmelt may reach the shallow workings in areas that were not accessible because of unstable ground or cave-ins. A major increase in discharge monitored on 9 Level occurred in late May and June 1999. No major increase in discharge in the shallower workings appeared to coincide with that event. This discussion is based in observations underground only. Follow up hydrograph interpretation is required to test these ideas.

High elevation snowmelt in the main channel of West Fork Milo Creek produces surface water that infiltrates up gradient of the hanging wall of the Guy Cave area. In addition, shallow groundwater in alluvium probably recharges the hanging wall of the Guy Caving area.

Shallow groundwater, and possibly some surface water, in the north basin of West Milo Creek appears to have a direct recharge route into the hanging wall of the Guy Caving area. The combination of surface topography and bedrock outcrops indicate that all surface and groundwater in that basin recharges the Caving area.

3.2 Objective 2

Objective 2 was to identify acid producing areas of the workings. The Flood-Stanly ore body is the primary acid producing area of the mine. Our initial concept at the outset of reconnaissance was that the shallow water would be fairly good quality, and that the quality would gradually degrade with depth. However, it was found that water quality within 50 feet of the surface already had degraded substantially in some areas. The upper portions of the narrow veins above the Utz discharge poor quality water. Ponded and slow moving water in the Flood-Stanly workings control water quality degradation to a much greater degree than does length of flow path.

3.3 Objective 3

Objective 3 was to understand mine water flow paths within the workings and evaluate the potential for mine water diversions. Flow paths within the workings are complex, dominated by low-gradient ditch flow along levels or sub-levels, leading to steeply dipping raises or transfers between levels. We developed a much more thorough understanding of flow paths which are presented in detail on the associated maps.

There are many potential types of acid mine water generation mitigations for the Flood-Stanly ore body. The following discussion presents conceptual ideas of types of diversions that could be applied to representative situations. Each idea would need to be evaluated in more detail, and in relation to the overall presumptive remedy. The following is not intended to be an exhaustive list. Rather, the following were possible mitigations that were discussed during our reconnaissance.

3.3.1 Backfilling

The Homestake and Utz workings are potentially amenable to backfilling with cemented backfill. The purpose would be to prevent water and oxygen from contacting pyrite, in turn causing oxidation and heating that causes localized snow melt and infiltration into the upper portions of the Flood-Stanly ore body. The backfill material could consist of the sand fraction from a conventional mill mixed with cement for structural integrity. Other amendments such as excess lime to buffer residual acid, or organic material to drive the system chemically reducing could be added if they were deemed desirable.

One concept would be to bulkhead the end of drifts on the sub-level below the Homestake and backfill all of the workings from that level up to the top of the sub-levels above the Utz. It may be simpler to mine the shallow veins in the Utz to the surface than to monitor placement of backfill to insure good distribution in the shallowest workings. This approach should be contrasted to surface capping because of the steep topography and heavy surface vegetation. However, neither option should be excluded at this time.

3.3.2 In-Mine Diversions

Collection and direct discharge of relatively clean water from the eastern end of 5 Level may be possible depending on discharge requirements. Diamond drill holes at the end of the New East Reed drift discharge relatively excellent quality water. Water flowing over the Russell Dam is of relatively excellent quality except for a short period of time during spring runoff, when the zinc concentration generally is less than 0.5 mg/L. However, it sometime spikes to substantially more than that for days at a time.

The source of the spikes of poor quality water is not known. However, the flow does not increase when the concentration increases. This indicates that the source is a small volume of very poor quality. An in-mine diversion probably could be constructed relatively easily that would permanently divert the water away from the Russell Dam to a discharge point that would be tributary to the Williams (5WM) or to 6 Level. The remainder of the water may be of sufficient quality (depending on discharge requirements) to discharge out the Reed of Russell portal, decreasing the hydraulic load at the treatment plant. Alternately, all drill holes in the New East Reed, and behind or otherwise tributary to the Russell Dam could be plugged.

This discussion of an in-mine diversion illustrates what probably is the typical utility of in-mine diversions. A discrete flow (good or poor quality) could possibly be diverted toward an alternate discharge path, but generally it does not appear that in-mine diversions to keep good quality water out of the Flood-Stanly ore body would be successful (see discussion of Objective 2). The major reason is that most of the water in the vicinity of the Flood-Stanly ore body is degraded by the time it reaches the accessible underground workings.

3.3.3 Diamond Drill Hole Plugging

Plugging of diamond drill holes could be useful in reducing the hydraulic load to the water treatment plant. However, discharge from drill holes does not appear to be a major source of direct recharge to the Flood-Stanly ore body. Two ways that drill hole discharge could be significant are if the clean water from drill holes mixes with poor quality water and produces chemical precipitates, or if the water finds the Flood-Stanly through a long flow path. Plugging of drill holes would likely require periodic maintenance to repair or replace packers/plugs that begin to leak.

A special case of drill hole plugging is the high capacity (high pressure?) drill hole on 7 Level. That hole discharges more than 100 gpm of relatively excellent quality water. This discharge contributes to the hydraulic load at the treatment plant. Another serious consequence of this discharge is its impact on ditch and track maintenance underground.

The water from this drill hole flows down the Bailey Ore Chute to 9 Level. It discharges approximately 50 feet from the bottom of the Cherry Raise. The poor quality water flowing down the Cherry Raise mixes with the good quality water from the Bailey Ore Chute, resulting in the precipitation of vast quantities of metal hydroxides in the ditch. This results in the need for extensive and frequent ditch maintenance. This has not been done recently, and the result is that the ditch has filled completely, and the sludge is building up on the tracks.

3.3.4 Pond Elimination

Demolition of dams and regrading of workings to prevent ponding underground may be a viable method to prevent water quality degradation in the Flood-Stanly ore body. Pyrite is ubiquitous and any standing water stands in contact with pyrite-rich material. It was our observation that virtually every pond that contained standing water, contained water with very high EC and low pH. This effort surely would decrease the amount of stored poor quality water that is available for seasonal flushing during spring runoff. It also would probably decrease water quality degradation during the drier parts of the year. However, it probably would require periodic maintenance every few years because chemical precipitation of solids, and movement deposition of muck during runoff may cause re-formation of ponds.

3.3.5 Surface Diversions and Capping

Diversion of water on the surface, to prevent infiltration and recharge to the Flood-Stanly workings appears to be the effort most likely to succeed in decreasing the majority of recharge to the Flood-Stanly ore body. Capping of the Guy Caving Area would greatly reduce infiltration of direct precipitation and run-on from areas that are not addressed by surface diversions.

As discussed previously, surface water and shallow groundwater in West Fork Milo Creek appear to be the major contributors of recharge to the Flood-Stanly. Both low-elevation and high-elevation snow packs need to be addressed. In addition, both basins, in the West Fork should be considered for diversions. The South Fork of Milo contributes recharge to the Flood-Stanly workings, but to a lesser degree than the West Fork. Surface runoff collection and diversion ditches should be considered in conjunction with stream diversions and surface caps.

3.4 Objective 4

Objective 4 was to identify missing hydraulic, acid, and metal load within the upper country loop (9LA and its tributaries) identified during the current mine water monitoring program. Exploration of accessible workings of 9 Level did not identify any significant unmonitored sources of discharge that would contribute to the flow imbalance at 9LA. Approximately 20 to 30 gpm of relatively good quality water drains from the Ramsey and Morgan ore chutes on 9 Level. These are located in the Bunker Hill East drift on 9 Level beyond the bottom of the Van Raise (9VR). Approximately 5 to 10 gpm of relatively good quality water flows down the Cherry Vent Raise on 9 level. This is located at the top of the 10 Level Ventilation Raise that carries exhaust air from 10 to 9 Level. No other significant discharges were found in any drifts, ore chutes, drill holes or fractures that bypass existing monitoring locations.

4.0 Summary and Conclusions

The following is a summary of the major reconnaissance findings:

- Flow within the Flood-Stanly ore body is complex, being a combination of low gradient ditch flow to steeply dipping manmade structures, and/or collapsed permeable ground.
- Ponding occurs in undulations in drifts, and develops in response to development of chemical precipitate dams, or constructed dams. Pyrite is ubiquitous in and around the Flood-Stanly ore body. When water sits in ponds in contact with pyrite, bacterially catalyzed oxidation occurs rapidly and water quality degrades.
- In-mine floods change flow paths and dynamics, by either depositing muck that forms dams or eroding existing dams.
- Poor quality water exists less than 50 feet below ground surface.
- Timing of recharge probably is controlled by 3 mechanisms:
  - Localized heating under snow in Utz and Homestake,
  - Low elevation snow melt to 5 and 6 Levels, and
  - High elevation snowmelt to 7, 8, and 9 Levels.

5.0 Recommendations

The following are recommendations for incorporation of these findings into the presumptive remedy process.

5.1 General Recommendations

- Evaluate and incorporate these finding as appropriate in the context of possible mitigations in the Presumptive Remedy. Move these finding through the next steps process currently underway.
- Evaluate the conceptual ideas presented in the implications section, and as appropriate, define potential mitigations in better detail, evaluate, and prioritize.
- Review previous investigations, compare those findings to the 1999 reconnaissance results, and resolve inconsistencies among findings.
- Determine the percentage of the Flood-Stanly ore body that we explored during 1999 reconnaissance, based on a review of existing mine maps. If a substantial percentage of the workings are inaccessible, then direct modifications of accessible workings may have only a limited benefit on acid production and metal transport on a whole.
- The 1999 reconnaissance has resulted in increased understanding of recharge mechanisms and flow paths. If specific remedial design needs, monitoring issues, or other considerations require better understanding of specific flow paths, then additional reconnaissance may be necessary.

5.2 Specific Recommendations

- Perform hydrograph analyses to test hypotheses concerning recharge mechanisms and in-mine flow paths. Evaluate 1999 hydrographs to test hypotheses of timing of peak runoff and metal concentration events, to clarify hypotheses concerning localized, low elevation, and high elevation snowmelt recharge mechanisms. Compare 1999 hydrographs to historical hydrographs to determine changes in timing, duration, peak flow/concentration that have occurred. This may clarify the types of hydraulic changes that have occurred, in response to weathering, hydrogeologic changes, and/or diversion construction.
- Perform focused confirmatory reconnaissance during peak runoff during Spring of 2000. It would be especially beneficial to test hypotheses of flow on 8 Level and develop insight on 7 Level. In addition, focused reconnaissance may be necessary to evaluate issues in support of remedial design or to monitor post construction effectiveness of selected remedies.
- Evaluate the use of salt (or other) tracers to test hypothesized recharge mechanisms, flow paths, or post construction diversion effectiveness.
- Use newly constructed maps of near surface, acid producing areas to delineate likely zones of recharge to the shallow Flood-Stanly ore body.
- Continue to develop accurate maps of underground workings, and their relation to surface features and possible recharge to the Flood-Stanly ore body. Incorporate these additions into the presumptive remedy conceptual model.
- Identify locations of acidic ponds and their volume of water and metals. Evaluate the potential benefits of dam/pond removal in terms of treatment plant O&M, remedial design, and/or post construction effectiveness monitoring.

Appendix A
Daily Reconnaissance Logs

Memorandum

To: Jim Stefanoff, CH2M HILL, Spokane

CC:

From: Bill Hudson, CH2M HILL, Kellogg

Date: 4-19-99

Re: Flood Stanly Recon on 4-16-99

John Riley and I did the first recon for the Flood Stanly evaluation portion of the project. On the enclosed map you will see additional workings on the Russell Level and a new down ramp to the Reed Level. Water paths are identified with arrows on the drifts. Two caves are also identified which stopped our progress that day. A large open stope on the NW portion of the diesel workings is identified as well. We did a quick evaluation of the up ramp system from the Asher drift to see if that would give us an idea of its vertical dimension. We believe that we were 60 feet above the 4 Level, but this will be confirmed next week if scheduling permits. Due to its location it will be important to determine this since considerable acidic water drains from the area. John took water quality parameters for matching of water on the Reed Level and these can be incorporated into the database this week. A distinct water course was identified in three draw points on the Russell Level, however on further thought, this will need additional evaluation to see if the water drains from predrilled areas and what is the orientation of the drill holes if that is the case.

RECONNAISSANCE LOG

CH2MHILL

TO:	Jim Stefanoff
FROM:	Bill Hudson
RECON LEVEL(S):	5 level
RECON DATE:	4-22-99
RECON TEAM:	John Riley, Nick Zilka and myself
ACCESS POINT AND ROUTES:	Reed access to 5 Level up ramp.
OBSERVATIONS: (attach map)	Surveyed 5 Level up ramp to intermediate access to open stope development. Continued survey to old workings that were cut by ramp. These turned out to be the Bunker Hill No. 4 Level at Reed Level + 100 feet. They in turn access an unknown service raise between 4 and 5 Levels. Continued ramp survey to top of open stope (top of ramp, + 60 feet to top of stope).
WATER QUALITY/FLOW ENCOUNTERED:	EC readings taken on select water sites on 5 Level, John has data in field book
COMMENTS/ RECOMMENDATIONS:	Service raise had water running down it towards 5 Level, water is of very poor quality and we are uncertain of where it ends up on the level without further investigations. Continue evaluation of this area in the near future is the best course of action as it could fill in many of the data gaps that we currently have. The open stope area makes considerable quantities of poor quality water and lies down dip of the leasor working, this plus water bearing structures in the area will need further research to gain necessary understandings of the system.

RECONNAISSANCE LOG

CH2MHILL

TO:	Jim Stefanoff
FROM:	Bill Hudson
RECON LEVEL(S):	3 Level
RECON DATE:	4-23-99
RECON TEAM:	Bill Hudson and John Riley
ACCESS POINT AND ROUTES:	Homestake Portal
OBSERVATIONS: (attach map)	Performed vertical profile work on North drift and some layout of next sublevel updip. Showed Willie Lujon, MSHA type of work we will be doing in F-S recon work. Willie took air samples and evaluated our work areas. Told us he wants one area bared down during next visit. Gave us a clean bill of health otherwise.
WATER QUALITY/FLOW ENCOUNTERED:	John took EC and flow measurements at various locations within the workings. Data recorded in his field logbook.
COMMENTS/ RECOMMENDATIONS:	Continue vertical profile work in area and access sublevel to determine where observable water flows are coming from.

RECONNAISSANCE LOG CH2MHILL

TO:	Jim Stefanoff
FROM:	Bill Hudson
RECON LEVEL(S):	3 Level, Homestake to UTZ
RECON DATE:	4-28-99
RECON TEAM:	John Riley, Nick Zilka, and Bill Hudson
ACCESS POINT AND ROUTES:	Homestake Portal, up through sublevels to UTZ, and UTZ Portal
OBSERVATIONS: (attach map)	Put together vertical profile maps of Hanging Wall Drift from the Homestake Level through 2 sublevels and then to the UTZ Level. Put together fairly good idea on water infiltration routes and pathways from the UTZ down to the Homestake.
WATER QUALITY/FLOW ENCOUNTERED:	John took EC readings on various pools of water on the sublevels. Data recorded in his field notebook.
COMMENTS/ RECOMMENDATIONS:	Continue working on filling in data gaps in this area and then start following flow paths down to Cherry 4 Level.

RECONNAISSANCE LOG CH2MHILL

TO:	Jim Stefanoff
FROM:	Bill Hudson
RECON LEVEL(S):	3 Level, UTZ
RECON DATE:	5-7-99
RECON TEAM:	John Riley and Bill Hudson
ACCESS POINT AND ROUTES:	Access through UTZ portal
OBSERVATIONS: (attach map)	Completed vertical profile map of UTZ workings from track level to top of stopes. Verified location of large open stope with respect to other near surface workings.
WATER QUALITY/FLOW ENCOUNTERED:	John took EC readings on various pools of water on the level. Water quality is degraded rapidly; water inflowing within 40 feet of surface has readings of 3-5000 and a pH of 2-3. Highest reading was 10,000 in a pool just inside of the caved portal. Data recorded in his field notebook.
COMMENTS/ RECOMMENDATIONS:	Remaining data gaps to be filled in include mapping out sublevel above Homestake that continues eastward, and sublevel profile above FW drift in Homestake. Mapping of Cherry 4 sublevel between 4 and 5 level open stopes, better detail on flow paths of water from 5 level upramp to the greenhouse area. This will complete analysis down to 5 level. Maximum of three days required completing this unless we run into some surprises.

RECONNAISSANCE LOG

CH2MHILL

TO:	Jim Stefanoff
FROM:	Bill Hudson]
RECON LEVEL(S):	2 and 4 Levels
RECON DATE:	5-13-99
RECON TEAM:	John Riley and Bill Hudson
ACCESS POINT AND ROUTES:	Through Sullivan No. 2 Portal and Homestake Portal to Cherry 4 Level
OBSERVATIONS: (attach map)	Measured service raise inclination, it is 61 degrees. Water pools on sublevel infiltrate down into Hanna stope and flow down the service raise. EC measurements were taken in area. On Cherry 4 Level traced out flow paths of water, defined probable split on water 's between Leasor workings and Guy Cave stoping area.
WATER QUALITY/FLOW ENCOUNTERED:	John recorded EC measurements on various pools on Cherry 4 Level, poor quality water for Leasor water and really poor quality water for Guy Cave stoping water.
COMMENTS/ RECOMMENDATIONS:	Follow-up work in upper levels includes one sublevel area to define and then finishing up flow paths from Cherry 4 Level down to 5 Level. This should be able to be done with 2 days of work if no unforeseen problems occur. Then work will proceed below 5 Level.

RECONNAISSANCE LOG CH2MHILL

TO:	Jim Stefanoff
FROM:	Bill Hudson
RECON LEVEL(S):	3 Level
RECON DATE:	5-17-99
RECON TEAM:	Nick Zilka, John Riley, and Bill Hudson
ACCESS POINT AND ROUTES:	Through Homestake Portal
OBSERVATIONS: (attach map)	Found source of water feeding SE drift on Homestake Level. Finished profiling sublevels above Homestake Level and also 2nd sublevel up in SE corner of workings, which is at approximate UTZ elevation.
WATER QUALITY/FLOW ENCOUNTERED:	John recorded EC measurements on pools of water in sublevels.
COMMENTS/ RECOMMENDATIONS:	This area is now completed, will proceed to 5 Level and complete area beneath Guy Cave and Leasor workings on Tuesday.

RECONNAISSANCE LOG CH2MHILL

TO:	Jim Stefanoff
FROM:	Bill Hudson
RECON LEVEL(S):	Bunker Hill 4 Level, 5 Level, and 6 Level
RECON DATE:	5-18-99
RECON TEAM:	Nick Zilka, John Riley, and Bill Hudson
ACCESS POINT AND ROUTES:	Reed Portal, through up ramp to B.H. 4 Level, down service raise to 5 Level, and Mule Raise to 6 Level
OBSERVATIONS: (attach map)	Recon on Bunker Hill 4 Level beneath Guy Cave area, considerable pools of poor quality water, on 5 Level, explored beneath Guy cave, also poor quality water, and considerable infiltration through transfers in area. On 6 Level traced flow paths of water from Becker Raise to Mule Raise and flow paths from Williams raise to Mule Raise. Also followed out flow path from Hanna Stope to Mule Raise.
WATER QUALITY/FLOW ENCOUNTERED:	John recorded water quality parameters on different levels, recorded some of the highest EC readings yet taken in mine on Bunker Hill 4 and 5 Levels.
COMMENTS/ RECOMMENDATIONS:	

RECONNAISSANCE LOG

CH2MHILL

TO:	Jim Stefanoff
FROM:	Bill Hudson
RECON LEVEL(S):	6,7, & 8
RECON DATE:	6-16-99
RECON TEAM:	Nick Zilka, John Riley, and Bill Hudson
ACCESS POINT AND ROUTES:	By way of Reed x-cut to Cherry Shaft and down shaft to levels
OBSERVATIONS: (attach map)	You don't pay us near enough for what we do. Were able to verify flow paths from 5.5 L. down through 8 L. in some areas. Recent evidence of higher flows on 6 & 8 Levels. Are able to better understand where high flows at Cherry Raise are coming from.
WATER QUALITY/FLOW ENCOUNTERED:	Small amounts of relatively good quality found near Cherry Shaft, considerable volumes of very poor quality water, EC readings to 50000+
COMMENTS/ RECOMMENDATIONS:	Next site to evaluate should be in the Mule raise area from 6 to 7L

Appendix B

Annotated Mine Maps (Figures 1-19)

KEY to COLORS - EC maps

< 500 μS/cm
500 - 2,000 μS/cm
2,000 - 5,000 μS/cm
5,000 - 10,000 μS/cm
10,000 - 20,000 μS/cm
> 20,000 μS/cm

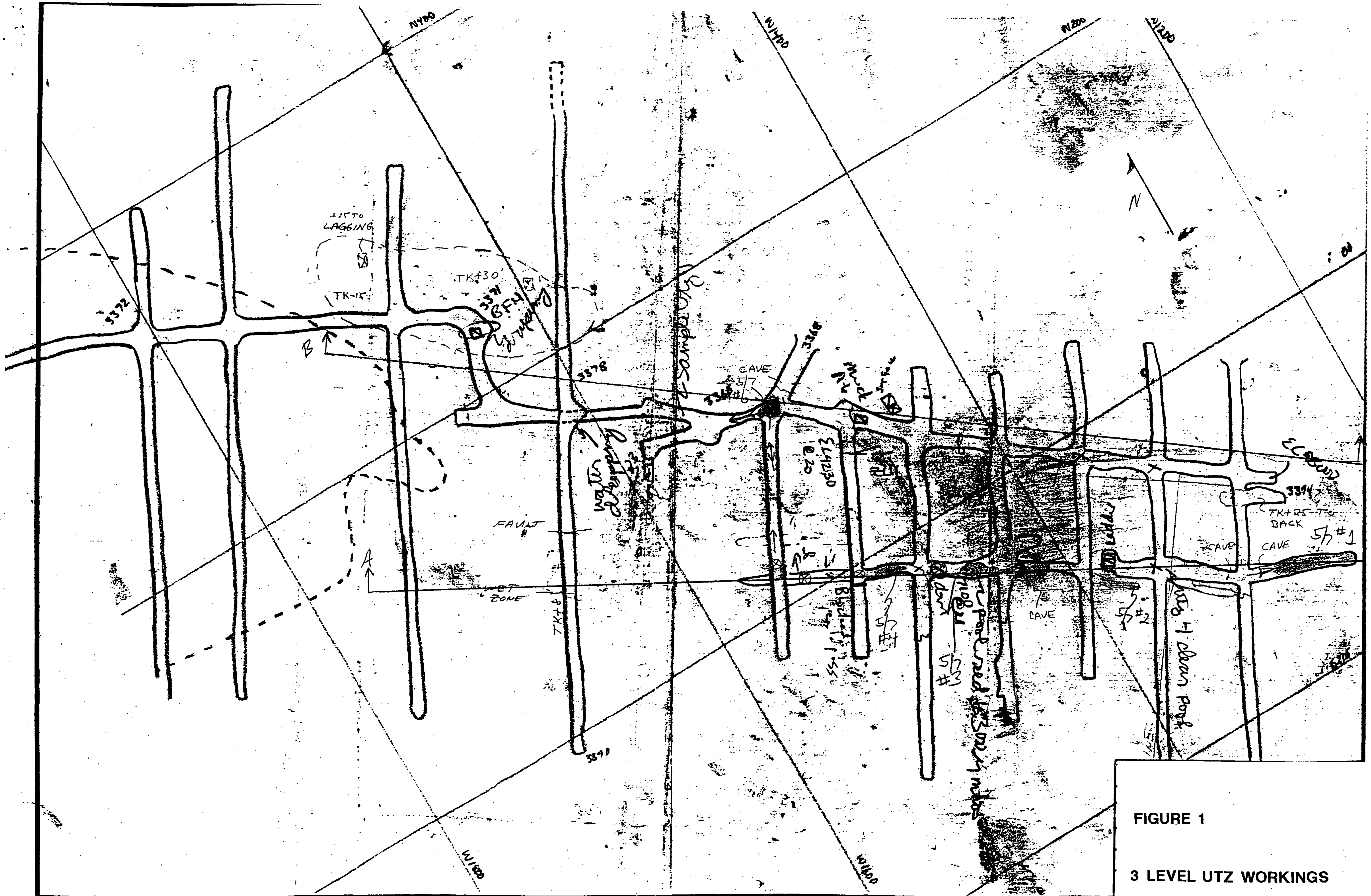


FIGURE 1

3 LEVEL UTZ WORKINGS

SCALE: 1"=50'

50 sc.

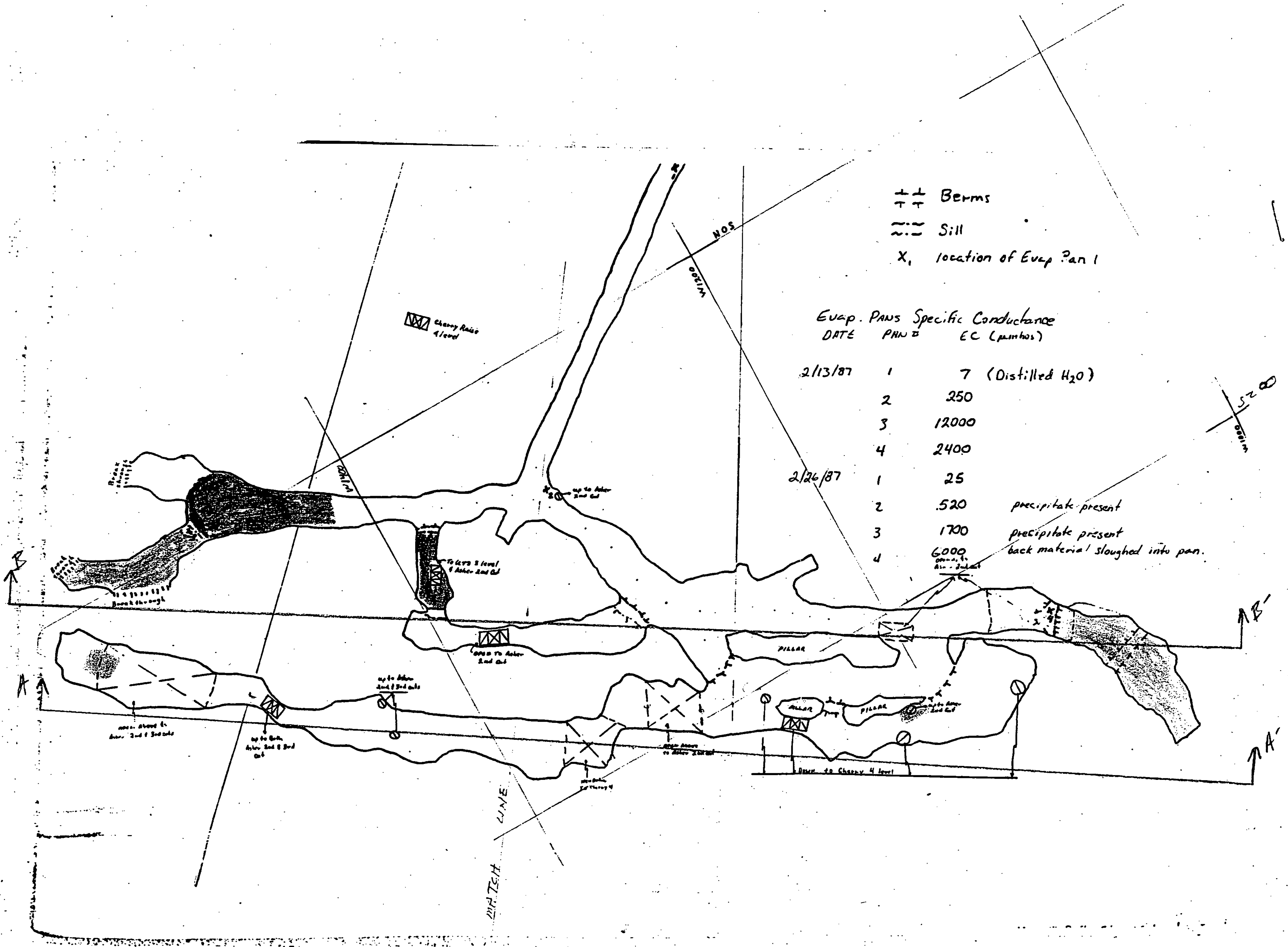


FIGURE 2

3 LEVEL HOMESTAKE WORKINGS

SCALE: 1"=50'

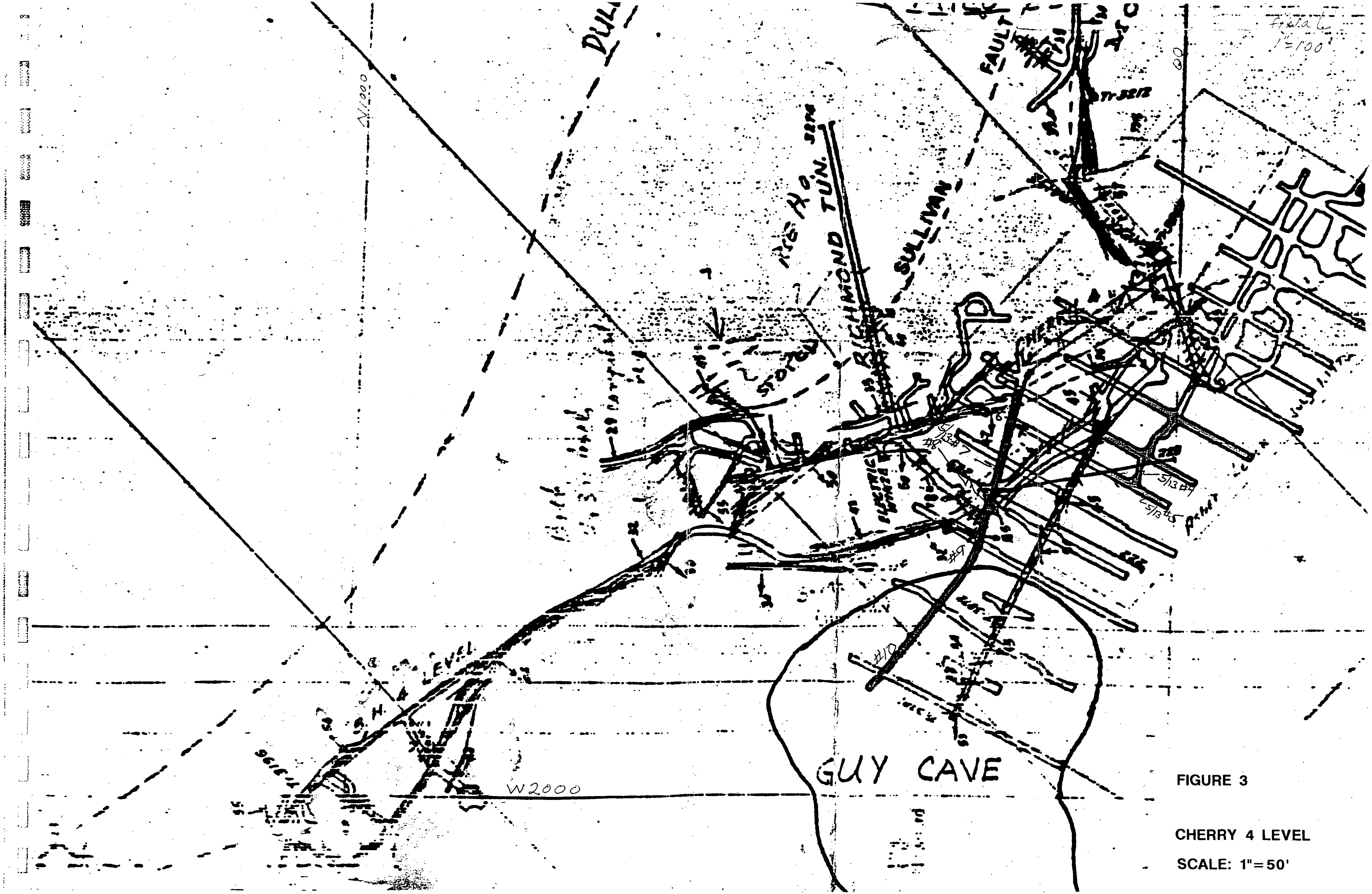


FIGURE 3

CHERRY 4 LEVEL

SCALE: 1"=50'

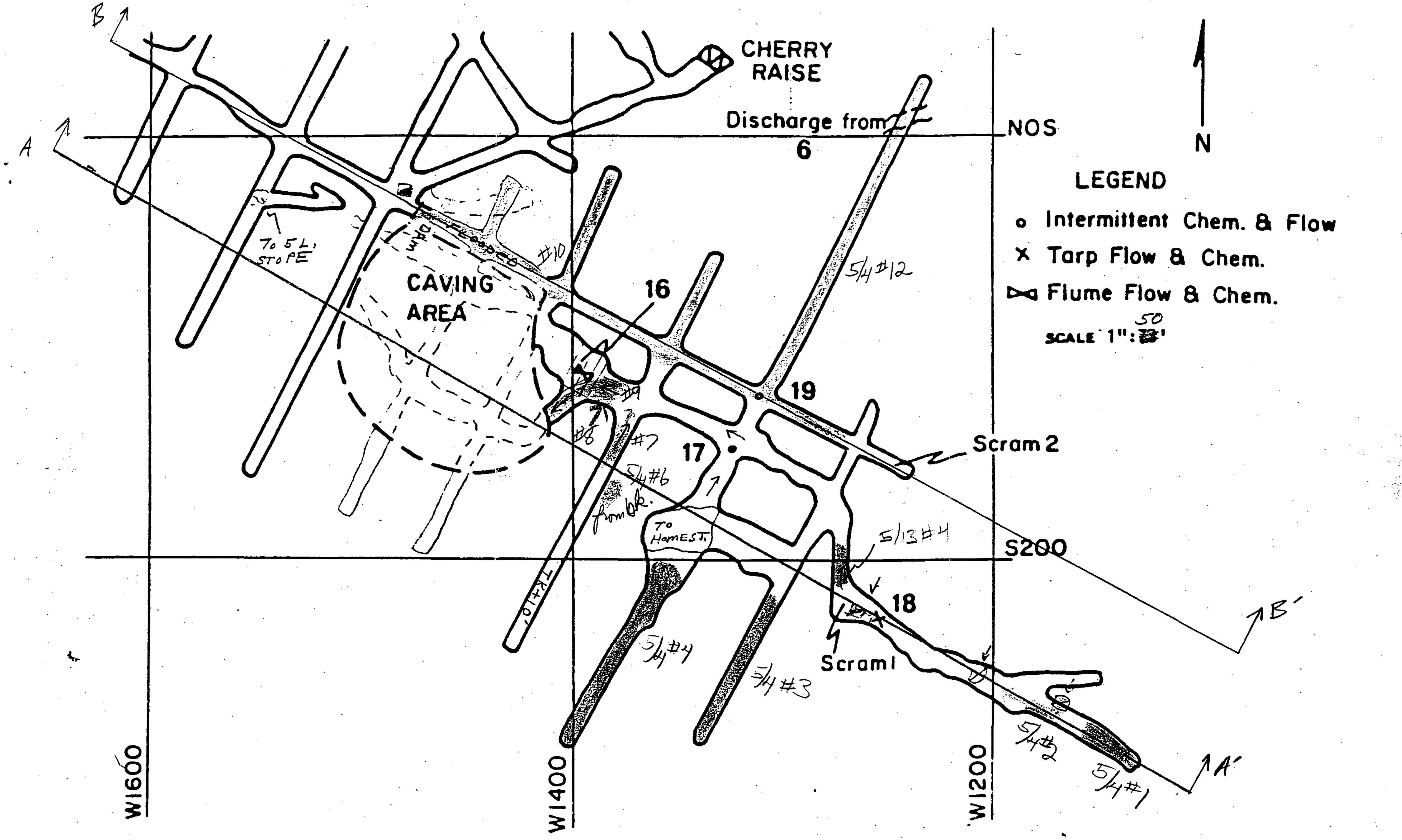


Figure 11. The Cherry 4 workings monitoring sites, Bunker Hill Mine.

FIGURE 4

CHERRY 4 LEVEL

SCALE: 1"=50'

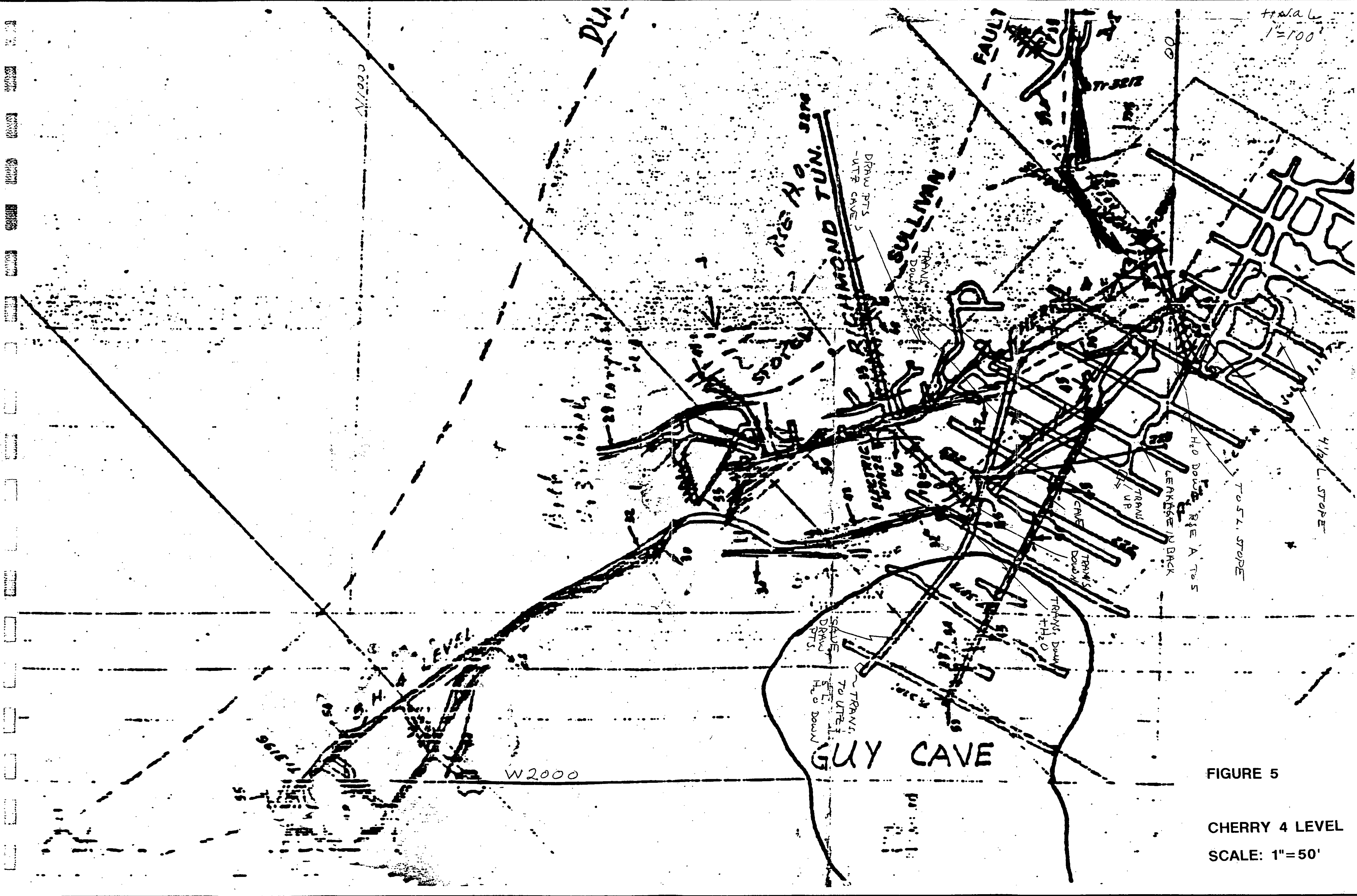
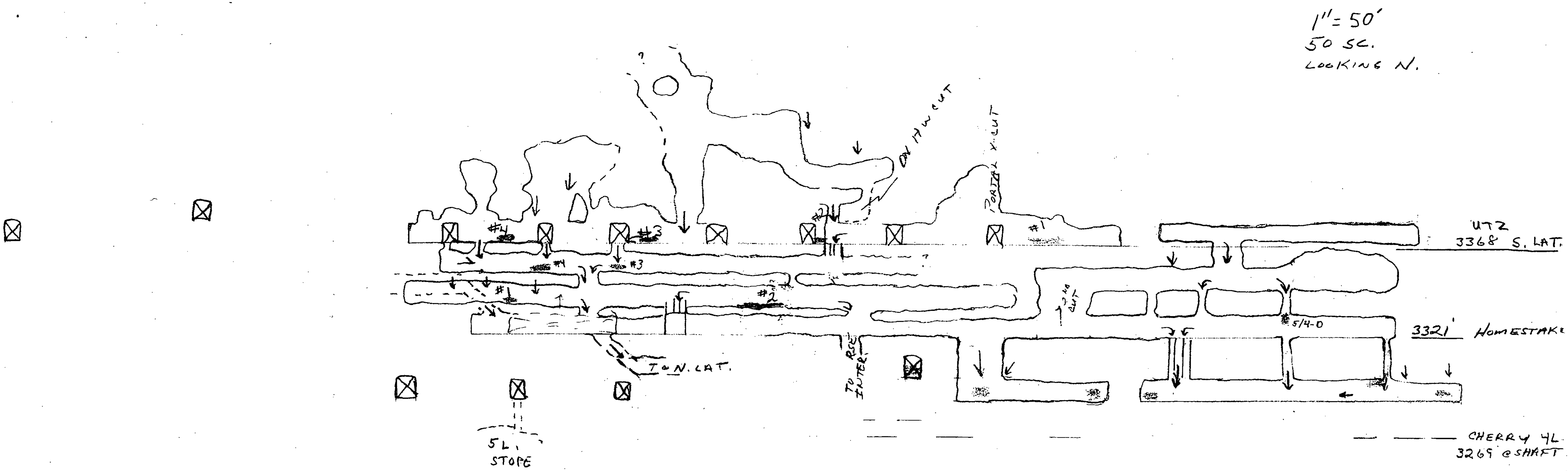


FIGURE 5

CHERRY 4 LEVEL

SCALE: 1"=50'



EC DATA FROM 4/28/99

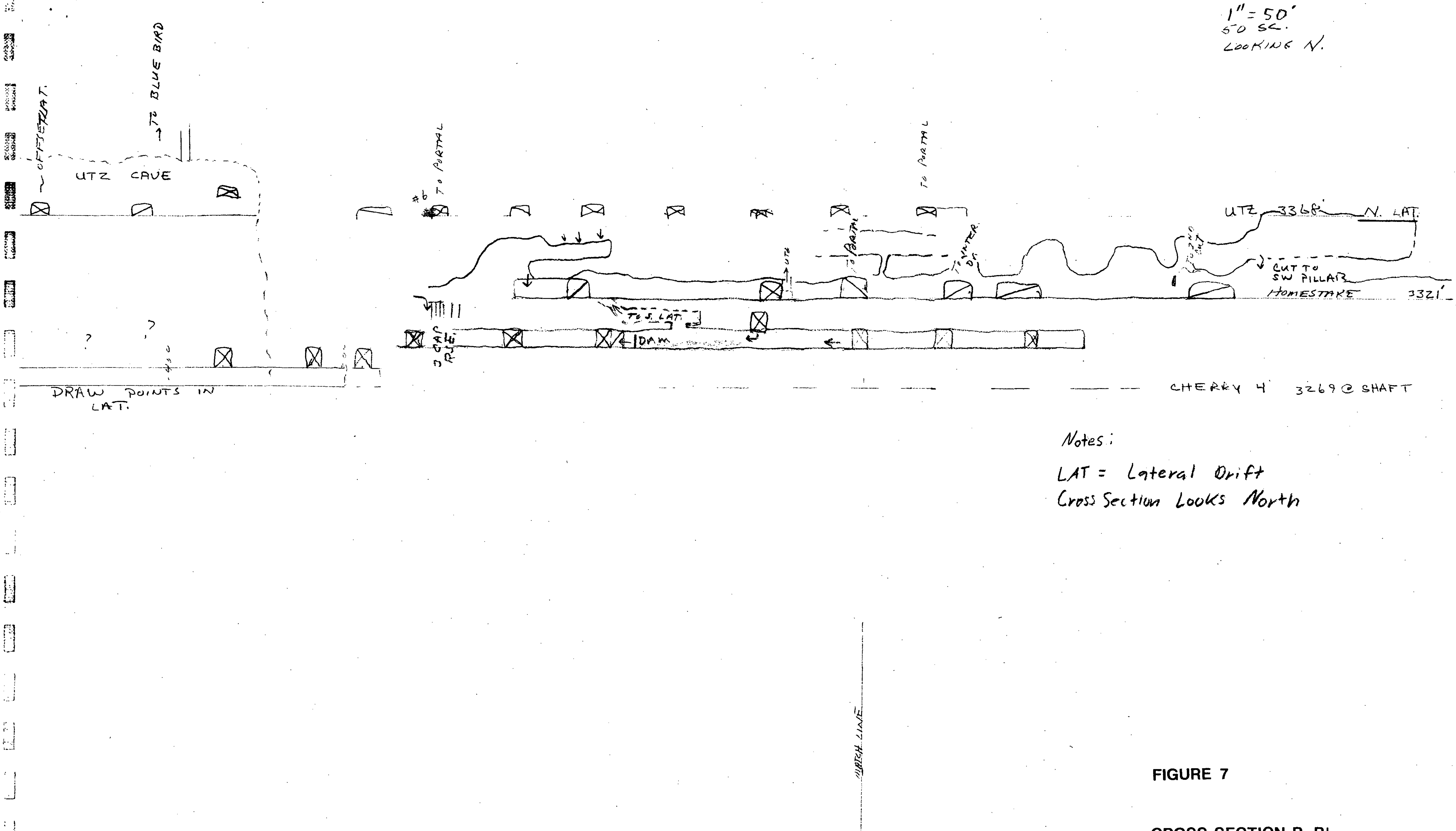
MATCH LINE

FIGURE 6

CROSS SECTION A-A'

(REFER TO FIGURES 1,2,4)

SCALE: 1"=50'



Notes:

LAT = Lateral Drift

Cross Section Looks North

FIGURE 7

CROSS SECTION B-B'

(REFER TO FIGURES 1,2,4)

SCALE: 1"=50'

FIGURE 8

5 LEVEL

SCALE: 1"=100'

FIGURE 9

5 LEVEL

SCALE: 1"=100'

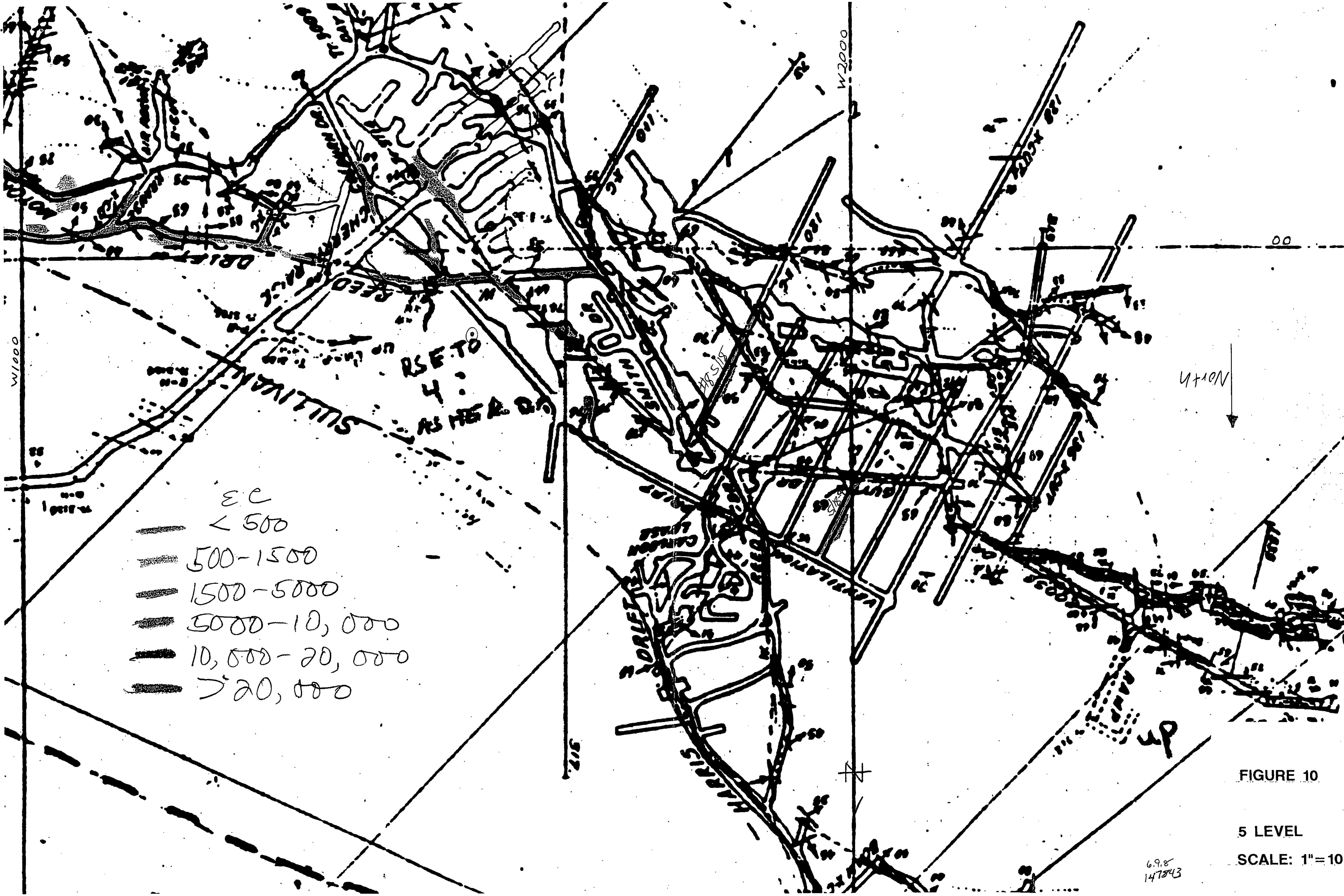


FIGURE 10

5 LEVEL

SCALE: 1"=100'

6.9.8
147843

5 LVL
1" = 300'
final

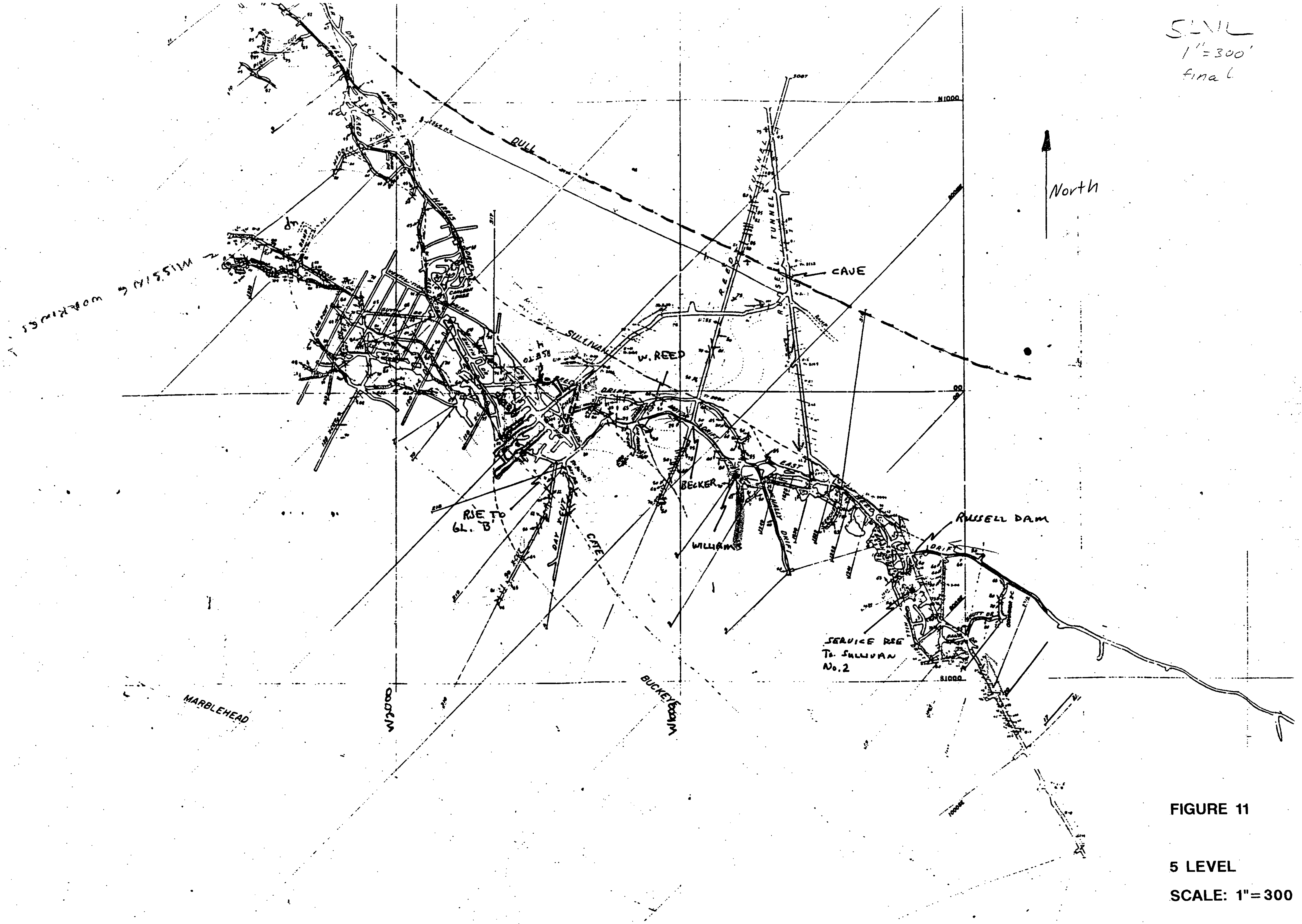


FIGURE 11

5 LEVEL

SCALE: 1" = 300

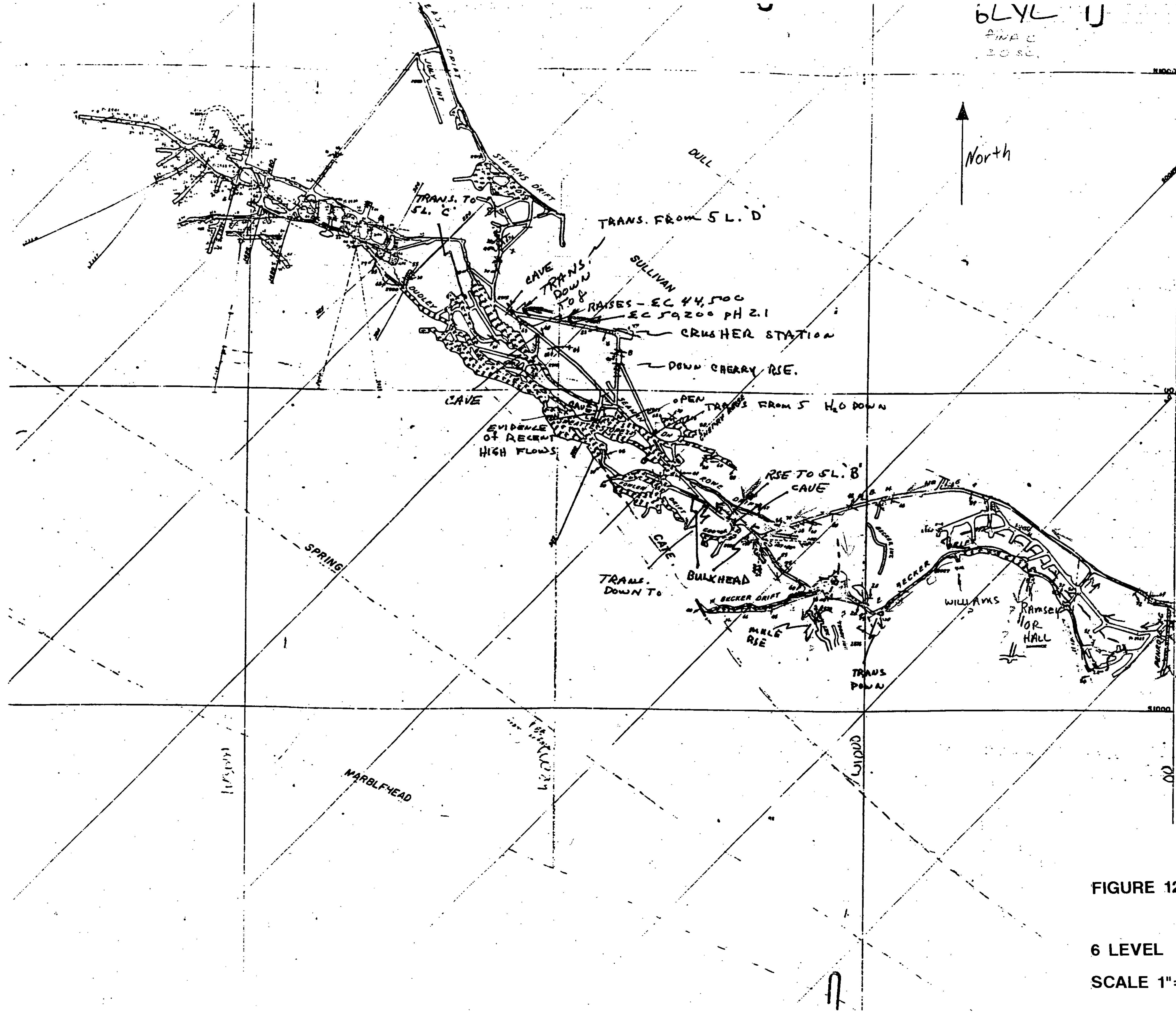


FIGURE 12

6 LEVEL

SCALE 1"=300'

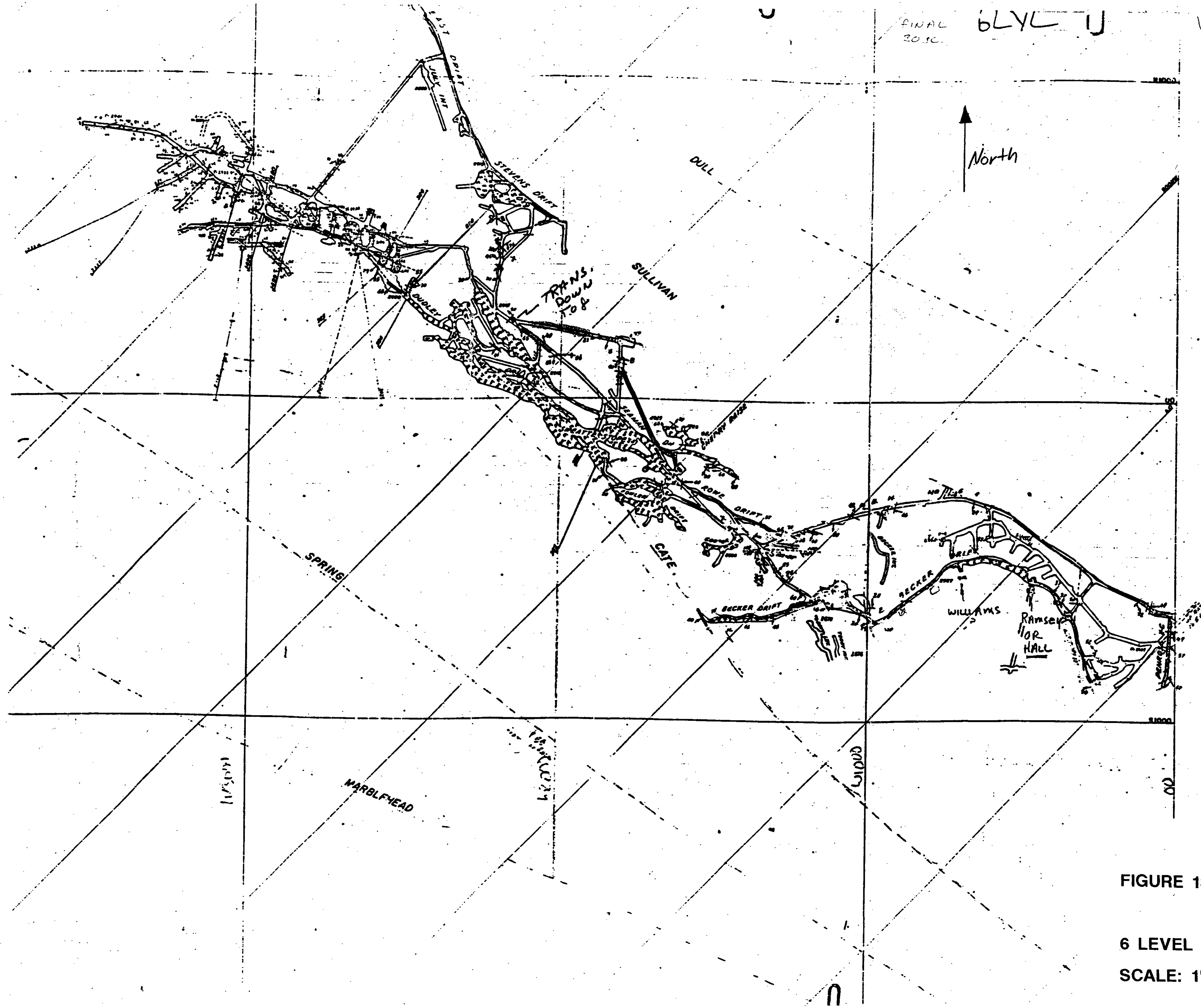


FIGURE 13

6 LEVEL

SCALE: 1"=300'

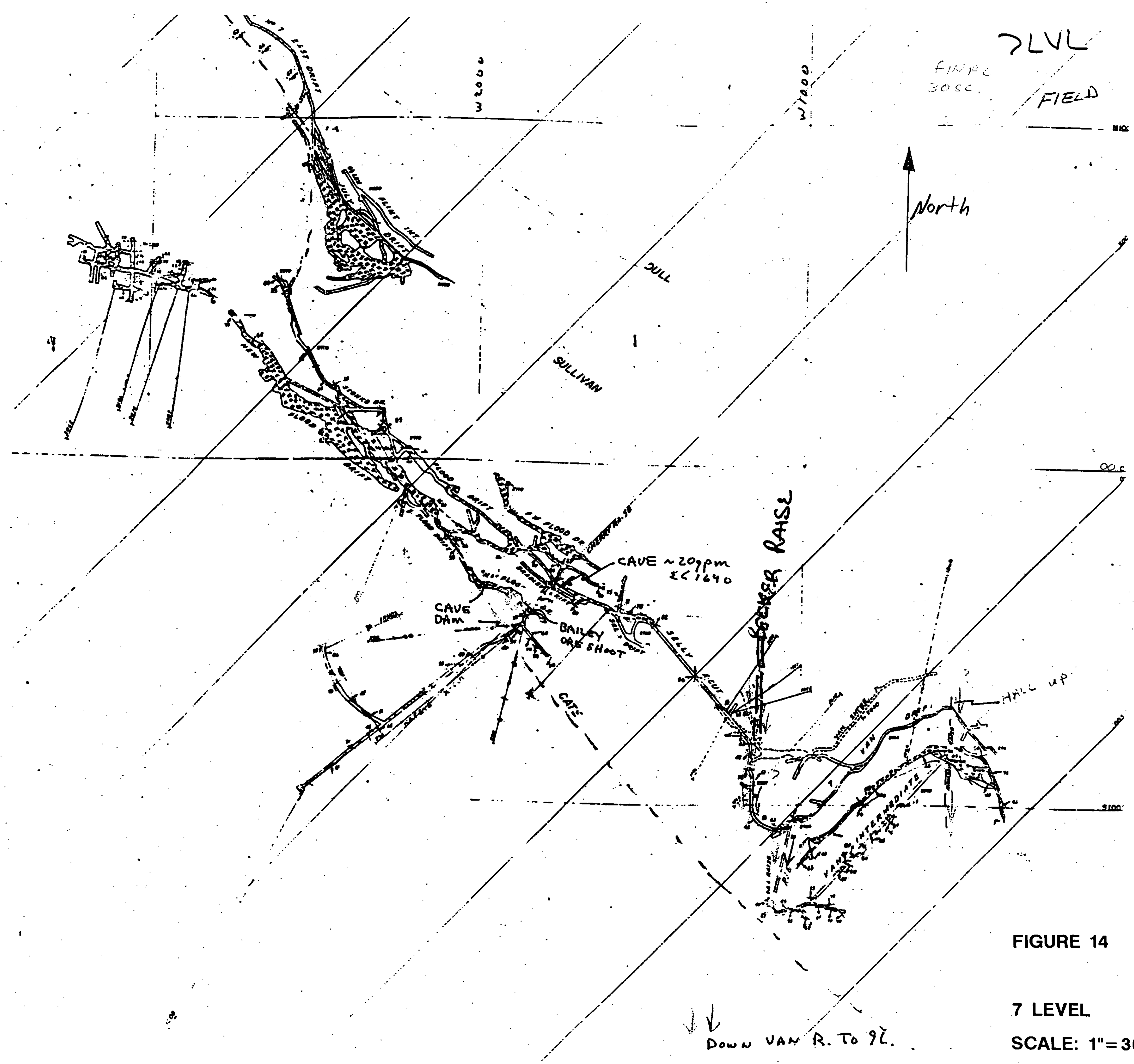


FIGURE 14

7 LEVEL

SCALE: 1"=300'

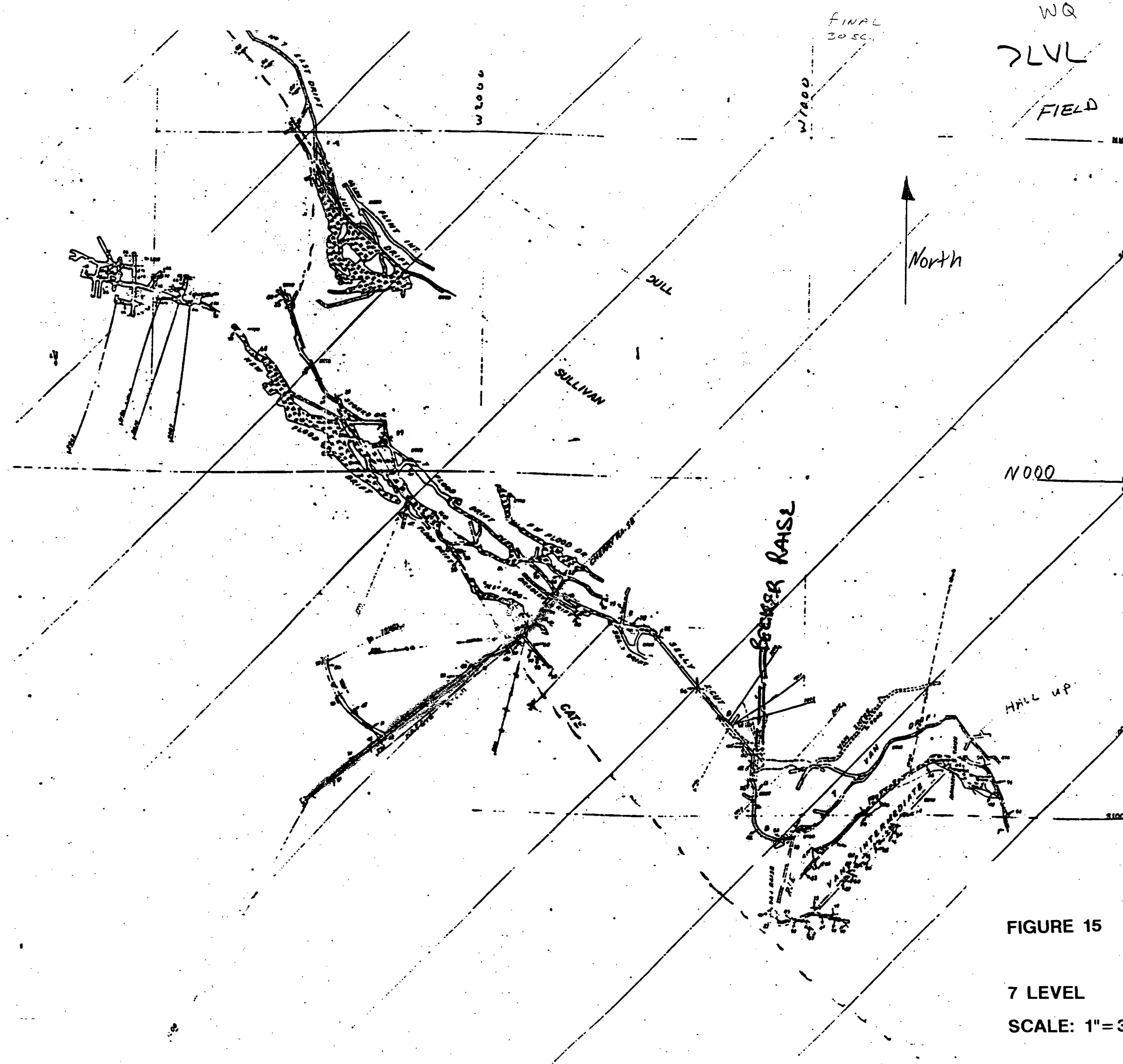


FIGURE 15

7 LEVEL

SCALE: 1"=300'

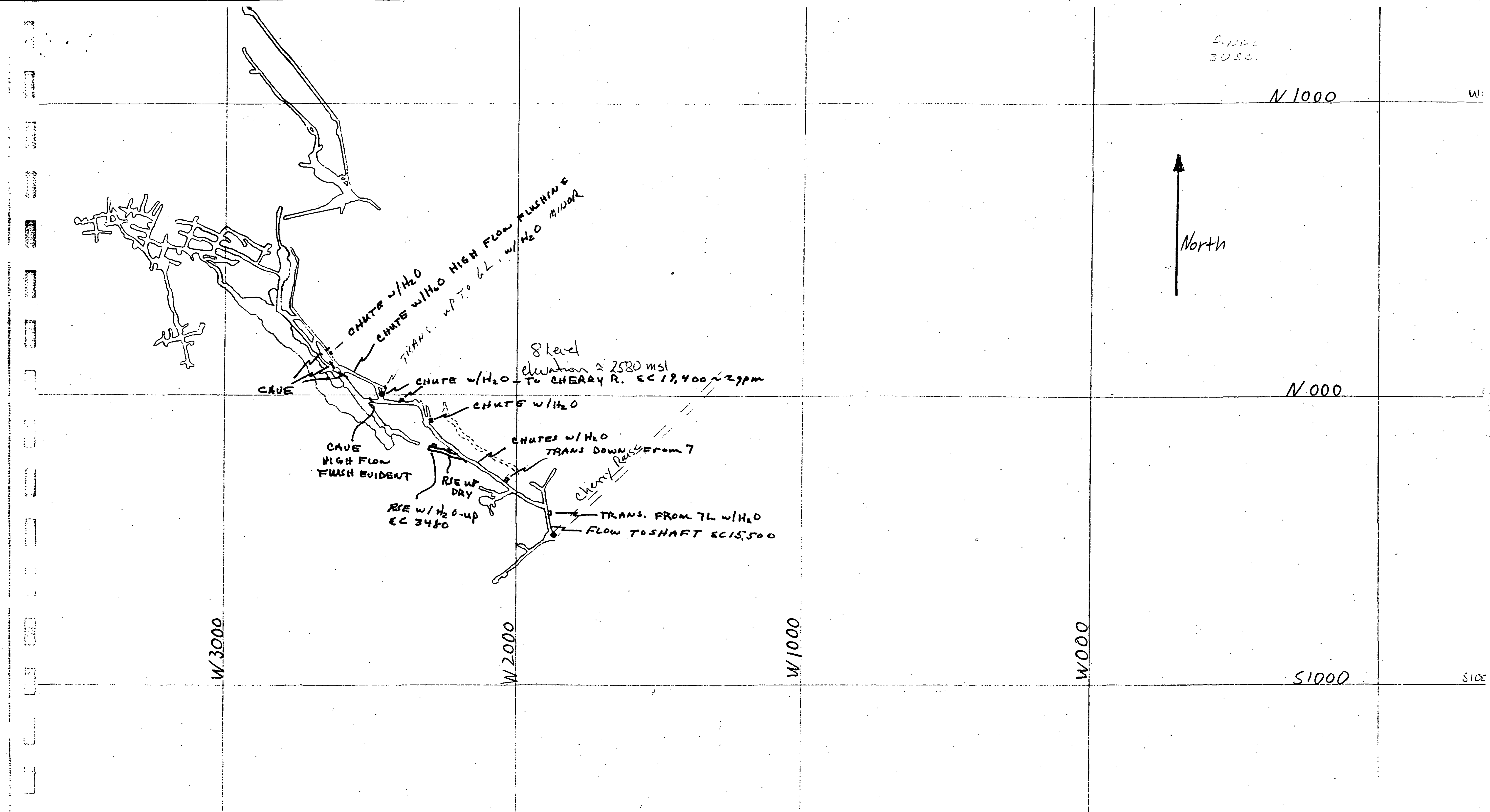


FIGURE 16

8 LEVEL

SCALE: 1"=300'

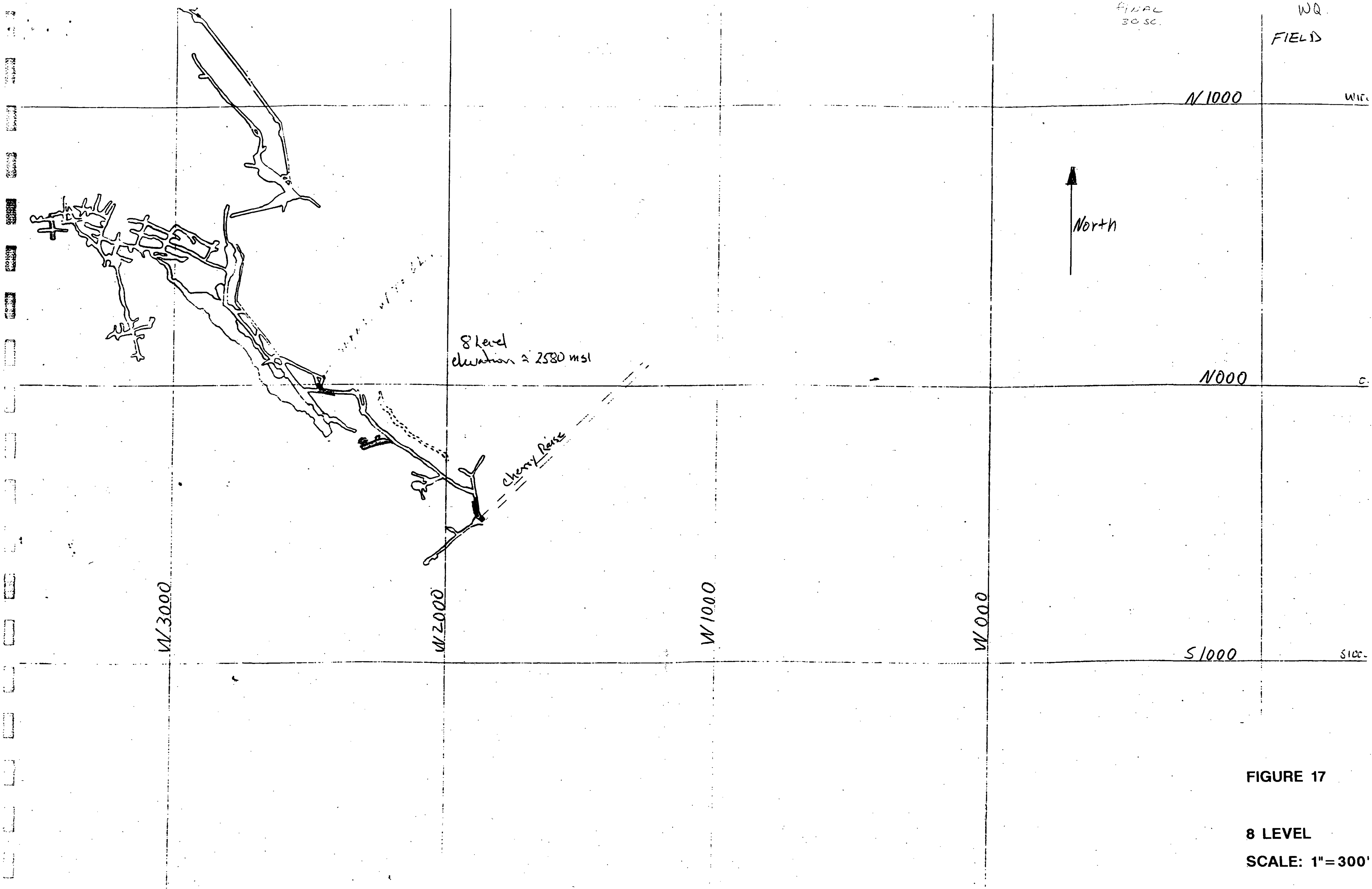


FIGURE 17

8 LEVEL

SCALE: 1"=300'

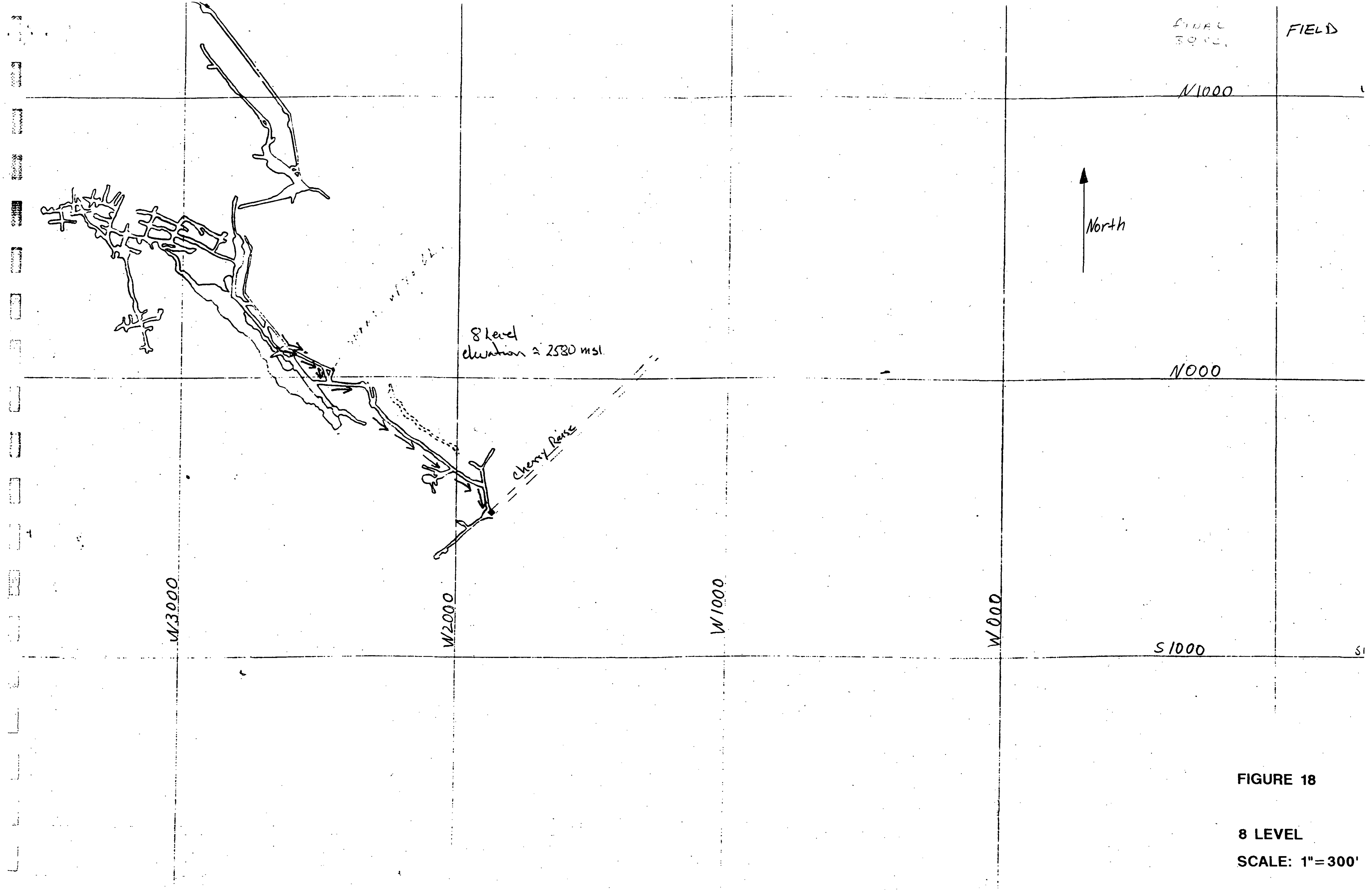


FIGURE 18

8 LEVEL

SCALE: 1"=300'

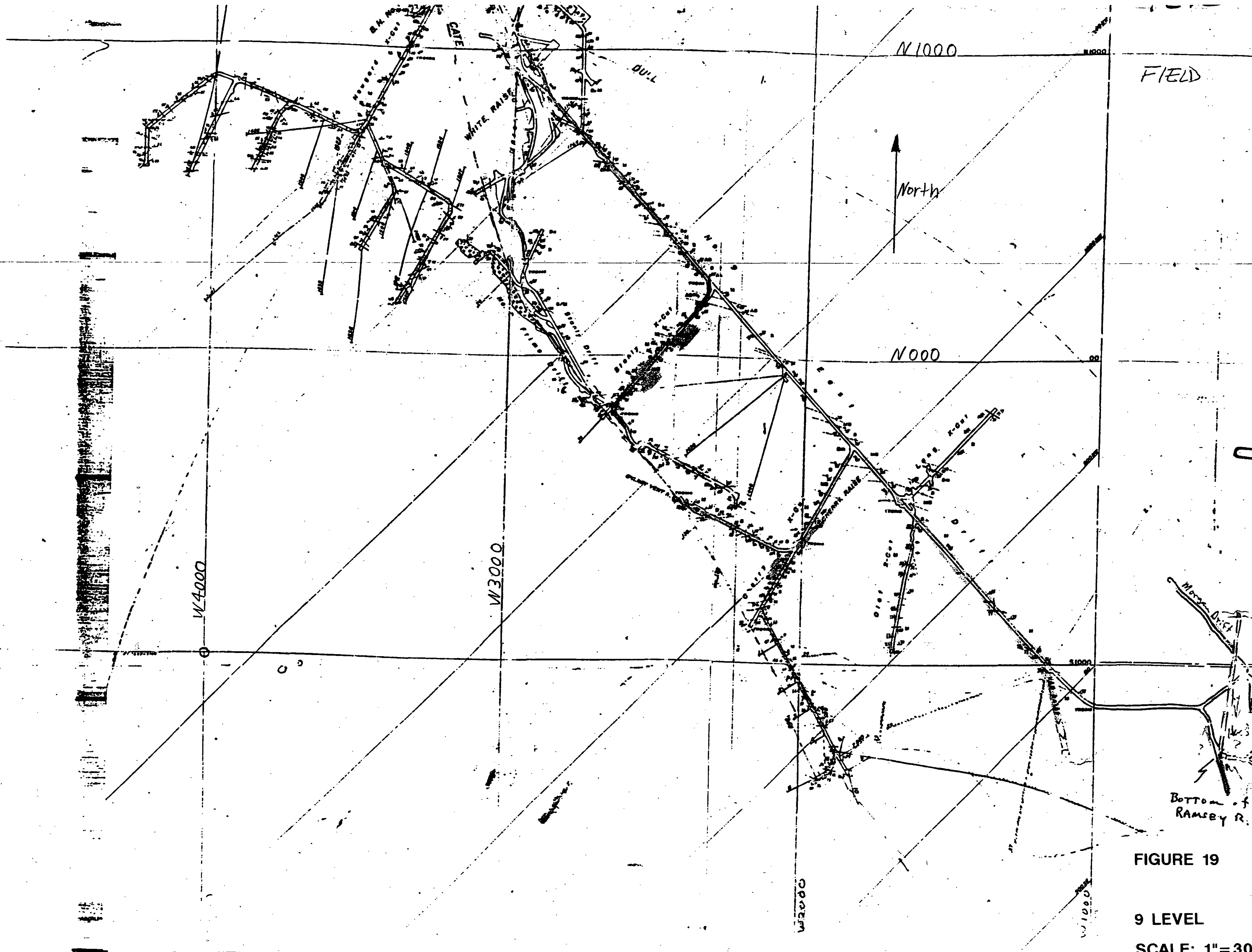


FIGURE 19

9 LEVEL

SCALE: 1"=300

Appendix C

Electrical Conductivity Measurements

(Sorted first by date, then by highest to lowest EC)

Flood Stanly In-Mine Reconnaissance
Field Conductivity Measurements

Sorted by Date

Sample ID (date-#) 1999	EC (microS/cm)	Remarks / Location
4/16-1	1,180	5 level Motor drift past Mule Raise
4/16-2	5,350	5 level Xcut upstream from 5WR
4/16-3	7,320	5 level at jct. of new up ramp and old drift near CR.
4/16-4	8,360	5 level (Russell) rock bolt in 1st drawpoint left of end of Asher
4/28-1	1,580	Homestake - HW drift north over muck pile from back
4/28-2	17,800	Homestake - HW sublevel above. Stratified: 15600 near surface
4/28-3	7,100	Homestake - HW drainage from sublevel above.
4/28-4	3,570	Homestake - HW sublevel above, left drift reflective of gouge zone.
4/28-5	7,390	Utz - HW drift to left
5/4-0	252	Homestake - HW very wet transfer drainage
5/4-1	482	Homestake: Sub-level below - HW drift pond at end on right. *
5/4-2	1,320	Homestake: Sub-level below. Down transfer - does not contibute to #1
5/4-3	2,330	Homestake: Sub-level below. 1st Xcut
5/4-4	458	Homestake: Sub-level below. Q ~ 1gpm
5/4-5		Sample number 5 skipped accidently.
5/4-6	648	Homestake: Sub-level below. Pond from dripping back
5/4-7	670	Homestake: Sub-level below. Water going over slide into HW drift.
5/4-8	4,030	Homestake: Sub-level below. Discharge from next ore chute.
5/4-9	3,050	Homestake: Sub-level below. Discharge into open stope.
5/4-10	6,350	Homestake: Sub-level below. Long flooded drift.
5/4-12	4,880	Homestake: Sub-level below. Long flooded drift - upstream from #10.
5/7-1	8,160	Utz - HW drift to left
5/7-2	3,390	Utz - unmapped drift beyond transfer raise
5/7-3	7,170	Utz - pond next to transfer with rail across it.
5/7-4	4,730	Utz - HW drift between transfers.
5/7-5	3,850	Utz - Ground water inflow from near-surface vein
5/7-6	10,300	Utz - Pond at caved portal drift and FW drift.
5/13-1	580	Sullivan #2 - at bottom of ramp
5/13-2	216	Sullivan #2 - from vug. Q ~ 1.5gpm.
5/13-3	450	Sullivan #2 - Vein pool.
5/13-4	2,910	Homestake - Sub-level below in lateral at bottom of raise.
5/13-5	2,980	Cherry 4 Xcut. (See map for detail.)
5/13-6	11,900	Cherry 4 Xcut. (See map for detail.)
5/13-7	22,600	Cherry 4 Xcut. (See map for detail.)
5/13-8	29,900	Cherry 4 Xcut at intersection.
5/13-9	23,100	Cherry 4 Xcut. (See map for detail.)
5/13-10	29,100	Cherry 4 Xcut. (See map for detail.)
5/17-1	10,700	Homestake - Sub-level above intermediate drift.
5/17-2	1,010	Homestake - Sub-level HW drift. Feeds wet transfer.
5/18-1	6,950	BH4 - 1st pond in Xcut above ramp from Asher.
5/18-2	12,600	BH4 - down low-angle raise into left drift.
5/18-3	33,200	BH4 - down low-angle raise into right drift.
5/18-4	39,900	BH4 - from #3 along drift, through door, down ~5 ft. Near transfer.

Flood Stanly In-Mine Reconnaissance
Field Conductivity Measurements

Sorted by Date

Sample ID (date-#) 1999	EC (microS/cm)	Remarks / Location
5/18-5	29,700	BH4 - farside of transfer of #4
5/18-6	18,000	From transfer to 5 LVL. Pond at bottom of raise, in greenhouse.
5/18-7	29,900	5 Level flooded transfer.
5/18-8	36,700	5 Level scram
5/18-9	44,600	5 Level scram ponded behind transfer.
5/18-10	41,000	5 Level - drift straight ahead from greenhouse air door, with ore car.
5/19-1	66	5 Level - 1st ore chute toward greenhouse from daylight switch.
5/19-2	132	5 Level - Xcut at WRF
5/19-3	1,210	5 Level - 1st ore chute on right.
5/19-4	4,730	5 Level - 2nd Xcut on left.
5/19-5	7,960	5 Level - top of Asher, pool at drawpoints.
5/28	251	9 Level - Cherry Vent Raisr
5/28	820	9 Level - Morgan Ore Chute
5/28	420	9 Level - Ramsey Raise
5/28	4,390	9 Level - Dull Raise
5/28	3,510	9 Level - Stanly Ore Chute #2
6/16	14,000	5 1/2 level - Drainage from transfer at end of open drift, near ladder up
6/16	8,860	5 1/2 level - second transfer, closer to Cherry Raise
6/16	1,640	7 level - L drift off CR. Discharge from lacing ~ 20 feet from CR.
6/16	15,500	8 level - drainage from Flood Stanly into CR
6/16	19,400	8 level - drainage down transfer near big open stope
6/16	3,480	8 level - last transfer sampled on way back to CR.
6/18	2,800	10 Level pump discharge
6/25	115	Last Chance #2 (or Songstad) pond at bottom of 1st ramp.
6/25	2,860	Discovery Cut
6/25	61	Phil Sheridan
Spring, 99	470	3HD
Spring, 99	3,300	5BK
Spring, 99	4,320	5WR
Spring, 99	370	5WM
Spring, 99	3,620	9KT
Spring, 99	5,300	9LA
Spring, 99	5,200	9SX
Spring, 99	19,100	9SO
Spring, 99	9,100	9CR
Spring, 99	180	9BO
Spring, 99	1,310	9VR
Spring, 99	3,820	9PU
Spring, 99	410	9BS

* This is the same level as Cherry 4 plus 10 feet.
Spring, 99 are maximum values for period of recon.

Flood Stanly In-Mine Reconnaissance
Field Conductivity Measurements

Sorted by Highest to Lowest EC

Sample ID (date-#) 1999	EC (microS/cm)	Remarks / Location
5/18-9	44,600	5 Level scram ponded behind transfer.
5/18-10	41,000	5 Level - drift straight ahead from greenhouse air door, with ore car.
5/18-4	39,900	BH4 - from #3 along drift, through door, down ~5 ft. Near transfer.
5/18-8	36,700	5 Level scram
5/18-3	33,200	BH4 - down low-angle raise into right drift.
5/18-7	29,900	5 Level flooded transfer.
5/13-8	29,900	Cherry 4 Xcut at intersection.
5/18-5	29,700	BH4 - farside of transfer of #4
5/13-10	29,100	Cherry 4 Xcut. (See map for detail.)
5/13-9	23,100	Cherry 4 Xcut. (See map for detail.)
5/13-7	22,600	Cherry 4 Xcut. (See map for detail.)
6/16	19,400	8 level - drainage down transfer near big open stope
Spring, 99	19,100	9SO
5/18-6	18,000	From transfer to 5 LVL. Pond at bottom of raise, in greenhouse.
4/28-2	17,800	Homestake - HW sublevel above. Stratified: 15600 near surface
6/16	15,500	8 level - drainage from Flood Stanly into CR
6/16	14,000	5 1/2 level - Drainage from transfer at end of open drift, near ladder up
5/18-2	12,600	BH4 - down low-angle raise into left drift.
5/13-6	11,900	Cherry 4 Xcut. (See map for detail.)
5/17-1	10,700	Homestake - Sub-level above intermediate drift.
5/7-6	10,300	Utz - Pond at caved portal drift and FW drift.
Spring, 99	9,100	9CR
6/16	8,860	5 1/2 level - second transfer, closer to Cherry Raise
4/16-4	8,360	5 level (Russell) rock bolt in 1st drawpoint left of end of Asher
5/7-1	8,160	Utz - HW drift to left
5/19-5	7,960	5 Level - top of Asher, pool at drawpoints.
4/28-5	7,390	Utz - HW drift to left
4/16-3	7,320	5 level at jct. of new up ramp and old drift near CR.
5/7-3	7,170	Utz - pond next to transfer with rail across it.
4/28-3	7,100	Homestake - HW drainage from sublevel above.
5/18-1	6,950	BH4 - 1st pond in Xcut above ramp from Asher.
5/4-10	6,350	Homestake: Sub-level below. Long flooded drift.
4/16-2	5,350	5 level Xcut upstream from 5WR
Spring, 99	5,300	9LA
Spring, 99	5,200	9SX
5/4-12	4,880	Homestake: Sub-level below. Long flooded drift - upstream from #10.
5/19-4	4,730	5 Level - 2nd Xcut on left.
5/7-4	4,730	Utz - HW drift between transfers.
5/28	4,390	9 Level - Dull Raise
Spring, 99	4,320	5WR
5/4-8	4,030	Homestake: Sub-level below. Discharge from next ore chute.
5/7-5	3,850	Utz - Ground water inflow from near-surface vein
Spring, 99	3,820	9PU

Flood Stanly In-Mine Reconnaissance
Field Conductivity Measurements

Sorted by Highest to Lowest EC

Sample ID (date-#) 1999	EC (microS/cm)	Remarks / Location
Spring, 99	3,620	9KT
4/28-4	3,570	Homestake - HW sublevel above, left drift reflective of gouge zone.
5/28	3,510	9 Level - Stanly Ore Chute #2
6/16	3,480	8 level - last transfer sampled on way back to CR.
5/7-2	3,390	Utz - unmapped drift beyond transfer raise
Spring, 99	3,300	5BK
5/4-9	3,050	Homestake: Sub-level below. Discharge into open stope.
5/13-5	2,980	Cherry 4 Xcut. (See map for detail.)
5/13-4	2,910	Homestake - Sub-level below in lateral at bottom of raise.
6/25	2,860	Discovery Cut
6/18	2,800	10 Level pump discharge
5/4-3	2,330	Homestake: Sub-level below. 1st Xcut
6/16	1,640	7 level - L drift off CR. Discharge from lacing ~ 20 feet from CR.
4/28-1	1,580	Homestake - HW drift north over muck pile from back
5/4-2	1,320	Homestake: Sub-level below. Down transfer - does not contibute to #1
Spring, 99	1,310	9VR
5/19-3	1,210	5 Level - 1st ore chute on right.
4/16-1	1,180	5 level Motor drift past Mule Raise
5/17-2	1,010	Homestake - Sub-level HW drift. Feeds wet transfer.
5/28	820	9 Level - Morgan Ore Chute
5/4-7	670	Homestake: Sub-level below. Water going over slide into HW drift.
5/4-6	648	Homestake: Sub-level below. Pond from dripping back
5/13-1	580	Sullivan #2 - at bottom of ramp
5/4-1	482	Homestake: Sub-level below - HW drift pond at end on right. *
Spring, 99	470	3HD
5/4-4	458	Homestake: Sub-level below. Q ~ 1gpm
5/13-3	450	Sullivan #2 - Vein pool.
5/28	420	9 Level - Ramsey Raise
Spring, 99	410	9BS
Spring, 99	370	5WM
5/4-0	252	Homestake - HW very wet transfer drainage
5/28	251	9 Level - Cherry Vent Raisr
5/13-2	216	Sullivan #2 - from vug. Q ~ 1.5gpm.
Spring, 99	180	9BO
5/19-2	132	5 Level - Xcut at WRF
6/25	115	Last Chance #2 (or Songstad) pond at bottom of 1st ramp.
5/19-1	66	5 Level - 1st ore chute toward greenhouse from daylight switch.
6/25	61	Phil Sheridan
5/4-5		Sample number 5 skipped accidently.

* This is the same level as Cherry 4 plus 10 feet.
Spring, 99 are maximum values for period of recon.